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Using Future Value Analysis to Select an Optimal Portfolio of Force Protection Initiatives

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THESIS

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List of Acronyms

AFI	Air Force Instruction
AFROC	Air Force Requirements Oversight Council
AO	Action Officer
FPB	Force Protection Battlelab
FVA	Future Value Analysis
POC	Proof of Concept
VFT	Value-Focused Thinking

Abstract

With the recent increase in terrorist activity, force protection has become a key issue for the Department of Defense. Leading the research for new ideas and concepts in force protection for the US Air Force is the Air Force Force Protection Battlelab (FPB). The FPB is charged with searching out force protection ideas and selecting those most worthy for future consideration. In 2002, a Value-Focused Thinking (VFT) hierarchy was created to help the FPB select those ideas that provided the most value to the Air Force and it's force protection goals. This research effort uses the Future Value Analysis (FVA) approach, a decision-making methodology, to provide a more accurate project selection tool to the FPB. FVA incorporates the ideals of multi-attribute utility theory, specifically using the VFT process, as well as linear programming optimization techniques, to provide an optimal portfolio of initiatives for the FPB to pursue. FVA provides a solution that optimizes the value of initiatives selected, while remaining within the organizational constraints of the FPB. This research provides a proof of implementation for the FVA process in the force protection environment.

USING FUTURE VALUE ANALYSIS TO SELECT AN OPTIMAL PORTFOLIO OF FORCE PROTECTION INITIATIVES

Chapter 1. Introduction

1.1 General Background

One of the increasingly popular methods for making large-scale decisions is through the use of decision analysis. Decision analysis provides a mechanistic approach towards choosing between alternatives based on foundational statistical methods. A more flexible method of decision making is obtained when decision analysis is combined with a Value-Focused Thinking (VFT) approach to create a decision making tool that incorporates the multiple attributes of a system that are important. The use of VFT tools and methods allows organizations to make decisions based on those aspects that they value the most. An example of this is seen in Turkey, where the iron and steel industry has applied the VFT methodology, allowing their decision makers to make more informed decisions when selecting research and development projects (Oral, 1991:871). It has recently become a popular tool for government agencies to use when making decisions as well. An example of this can be seen by the use of decision analysis processes to satisfy the General Accounting Office and Bureau of Reclamation regarding the environmental projects in the Grand Canyon National Park region (Flug, 2000:270).

The principles of VFT are centered on a fundamental objective, which is the underlying question that an organization wishes to answer. The fundamental objective can range from looking for a solution to a particular problem of interest, to obtaining the list of projects that an organization can pursue to get the best value for its time and money. The fundamental objective is then broken down into its relative subcomponents, which are further decomposed until they are as specific and simple as possible. This creates the necessary hierarchical value structure, or value tree, that will serve as the decision making tool. Through each level of the tree structure, known as layers or tiers, weights are assigned to each of the components; these weights are indicative of the relative importance of the values they are assigned to. At the lowest levels of the tree, evaluation measures are assigned to all components. Different alternatives that satisfy the fundamental objective are then generated and scored based on the evaluation measures created. The alternatives with the highest scores are those that provide the most value to the organization.

Once scores are determined for each alternative, the VFT process is complete. Post analysis is then required to determine the optimum solution that answers the fundamental objective. One method of deciding the best alternative is to rank them in descending order to provide a list of possible initiatives to pursue. While this list is a good starting point for choosing between the initiatives, it does not necessarily provide the best solution for the organization. There are numerous external and internal constraints that will be placed on the organization. These constraints are not analyzed or accounted for in the VFT model.

To fully exploit its resources, an organization must pursue an optimized solution in its decision making process. There are many methods of optimizing an alternative selection solution. One particular method is through the use of linear programming. Using linear programming techniques, an organization can get the most value from its decision choices. Every organization has a finite amount of available resources. These same resources are required to pursue the various initiatives and projects that are being pursued. Linear programming can be used to optimize a model by generating constraint equations based on these finite resources.

1.2 Specific Background

The Air Force Force Protection Battle Lab (FPB) was established in 1997 with the mission of "[identifying] innovative concepts for protecting Air Force personnel, facilities and weapon systems, and rapidly measure their potential for advancing Air Force core competencies and joint warfighting by using field ingenuity, modeling, simulation, and actual employment of exploratory capabilities in operational environments"(Department of the Air Force, 1997). The FPB has the unique responsibility of selecting new force protection initiatives for the Air Force and testing these initiatives through proof of concept demonstrations.

A recent study established a sound defensible methodology for the FPB to select these initiatives based on a VFT hierarchy developed with FPB personnel and decision analysis experts (Jurk, 2002). The FPB VFT hierarchy is defined as a "gold standard" because it is based directly off of official policy and guidance, in this case Air Force

instructions and doctrine. The "gold standard" lends credibility to the structure, and creates an end decision-making tool that is defendable in nature. Air Force instruction defines four basic principles for battle labs to follow: be Lean, be Unique in your service, be Focused and specific, and be Innovative (have an impact on the Air Force mission and objectives). These four principles are the foundation of the FPB value hierarchy (Jurk, 2002) and are the foundation for all decisions made regarding initiative selection. The VFT hierarchy contains 30 evaluation measures that were selected by their respective area experts at the FPB. The weighting of the VFT tiers was accomplished by both the FPB commander and the various action officers assigned to the FPB initiatives, with the top two tiers weighted by the commander and the remaining three tiers weighted by the action officers.

1.3 Research Problem

Since the recent acts of terrorism against the United States, homeland security has received new interest and new directives. The FPB is the major research facility regarding AF Force Protection issues, and as such is in a state of change. This research effort will involve a reanalysis of the existing FPB VFT hierarchy and the development of a linear programming solution to provide a portfolio of initiatives that provide the most value within the allotted resources. Although the Jurk (2002) study produced a credible VFT model, there is a need to address the value hierarchy again in light of these recent force protection issues. A need also exists to provide a methodology that will allow the FPB to make a decision that is optimal, based on the constraints placed on their organization.

1.4 Research Objective

The purpose of this research effort is to demonstrate the usefulness of the future value analysis (FVA) process in the force protection environment. Future value analysis is a "combination of three methods to assess future opportunities: (1) a strategic assessment of future opportunities and challenges, (2) a multiple-objective decision analysis using value-focused thinking, and (3) a portfolio analysis using optimization" (Parnell, 2002). The research results facilitate the continued evolution of an FPB value model that allows the conversion of subjective organizational values into an objective methodology for ranking innovative force protection ideas according to the potential benefit (i.e., value) provided to the warfighter. This methodology lends itself to sorting through many ideas to extract those most closely aligned with the values, and subsequently the mission, of the FPB. This methodology ultimately aids the FPB DM in selecting the final ideas they pursue as initiatives. This research effort provides a process that lends insight to the FPB commander regarding the value of potential initiatives, ultimately allowing FPB initiatives to be selected in a defensible, objective, and repeatable way.

1.5 Research Question

The questions this research effort answers are: (1) Can last year's VFT model be validated and revised to better suit the FPB mission and objectives? (2) Can the model be implemented in a usable software form that benefits the FPB in the future? and (3) Is there a feasible solution that provides the optimal selection of a portfolio of initiatives while adhering to the constraints placed upon the FPB?

1.6 Review of Chapters

Chapter 2 consists of a literature review to provide background on the FPB and identify methods used by other organizations to construct their value models. Chapter 2 also discusses Future Value Analysis and its subcomponents. Chapter 3 further demonstrates the employment of Future Value Analysis, specifically the validation and revision of the existing VFT model (Jurk, 2002) and the subsequent optimization of that model using linear programming techniques. Chapter 4 documents an analysis of the model with a sample of ongoing FPB initiatives to determine its robustness, identify potential holes in the value hierarchy, and look for value gaps in the ongoing initiatives. Chapter 5 discusses the findings of the model analysis and draws conclusions on the appropriateness of the model for use within the force protection arena. Chapter 5 also highlights the impact of this research effort and makes recommendations for future model modifications and research. Finally, the value model is presented to the FPB for future use in their initiative selection process.

Chapter 2. Literature Review

This chapter summarizes information pertaining to force protection in the Air Force as well as information available on the Air Force Force Protection Battlelab (FPB), the Air Force agency charged with evaluating innovative force protection ideas. This literature review also provides references and details for the future value analysis process and its relevance to this research. Finally, this chapter outlines various literature on optimizing a project selection model using integer programming techniques.

2.1 Force Protection and the FPB

With the recent surge of terrorist activity, force protection has become a major concern for the military services. The U.S. military carefully defines force protection in the Universal Joint Task List (UJTL). The UJTL, a joint force tool developed to standardize the ideas and language used between joint and multinational units describes force protection as those acts that

> conserve the force's fighting potential so that it can be applied at the decisive time and place. [To include] actions taken to counter the enemy's forces by making friendly forces (including operational formations, personnel, etc.), systems, and operational facilities difficult to locate, strike, and destroy. This task includes protecting joint and multinational air, space, land, sea, and special operations forces; bases; and essential personnel; and [lines of communication]…from enemy operational maneuver and concentrated enemy air, space, ground, and sea attack; chemical and biological warfare; and terrorist attack. This task also pertains to protection of operational level forces, systems, and civil infrastructure of friendly nations and groups in military operations other than war. (Department of Defense, 1999:Ch 2, 413)

This definition encompasses all forms of threat on all military assets.

The Air Force adheres to the same definition set forth in the UJTL. The primary organization for developing new ideas and exploring technologies in this area is the Air Force FPB. Established in 1997, the Air Force FPB was one of six Air Force Battlelabs (a seventh was later added) created to "rapidly [identify] and [prove] the worth of innovative and revolutionary operations and logistics concepts" (Department of the Air Force, 1997:1) in their respective technical areas. The creation of the AF FPB was in direct response to increased threats to Air Force personnel around the globe. Specifically, the investigative report into the bombing at Khobar Towers in Saudi Arabia (Downing, 1996) was a major driving force behind the FPB's creation.

The FPB was designed, like the other six battlelabs, to operate on four fundamental principles: be lean, be unique, be focused, and be innovative (Department of the Air Force, 1997). The FPB is set up with an assigned cadre 25 people operating on a limited budget using limited infrastructure (Department of the Air Force, 1997). This principle of leanness serves to constrain the resources available and is of particular interest in this research effort as an optimization model constraint. The principle of uniqueness dictates that the FPB should prove concepts and ideas, not manage systems or projects. This principle further ensures there is no duplication of work; the FPB must center their effort on ideas and concepts that are not being pursued by other agencies. The principle of focus directs the FPB to leverage existing resources to the best of their ability. This can be done in a number of ways including leveraging existing technology available in both the commercial and governmental sectors, as well as employing existing contracts to leverage. The final principle of innovativeness drives the FPB toward advancing Air Force core competencies and supporting the joint warfighter (Department

of the Air Force, 1997). The FPB, within the direction and constraint of it's four fundamental principles, is ultimately tasked with selecting initiatives to fund, support, and pursue. A complete process flow chart of the FPB initiative selection process is shown in Figure 1. Initiatives can be generated both internally (e.g., from FPB personnel) and externally, via other agencies and organizations. External ideas can come from the Air Force Major Commands (MAJCOMs) or from non-governmental agencies (industry) in response to a broad area announcement. Once ideas are generated, they are screened for inclusion in the selection process. Those models that are remaining after screening are then reviewed and evaluated to determine which will be supported; it is this phase that is the focus for this research effort. Once the FPB commander decides on which initiatives to support, the initiatives are implemented. This research will detail how the future value analysis process can be used to help select these initiatives in the proposal evaluation phase shown in Figure 1; this process flow chart was created by Dave Taylor, a consultant to the FPB.

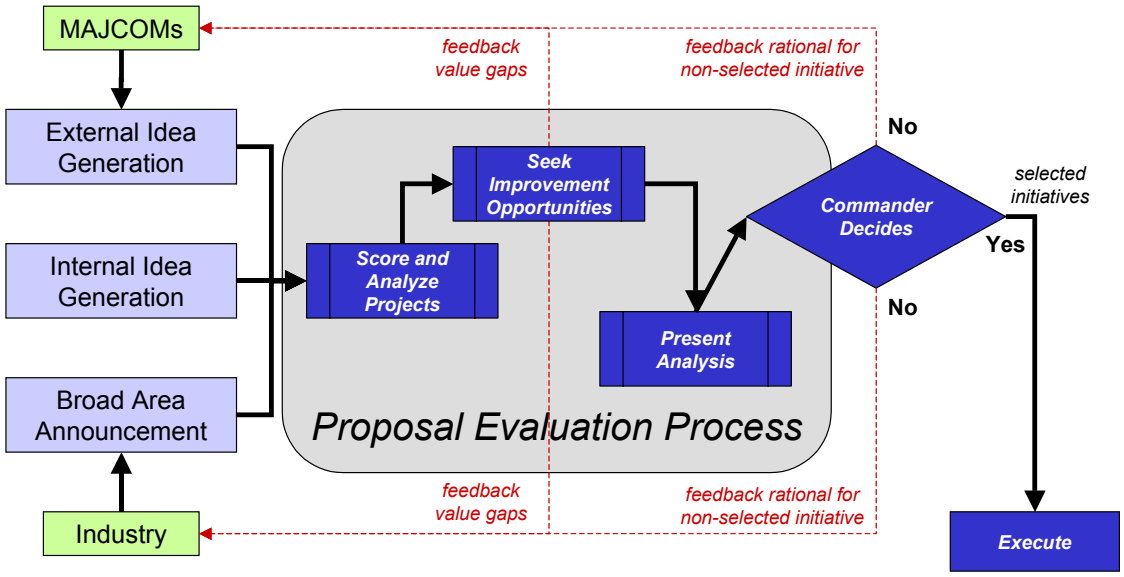


Figure 1. FPB Initiative Selection Process

2.2 Future Value Analysis

Future Value Analysis (FVA) is a structured decision making methodology that allows an organization to "develop and analyze future opportunities" (Parnell, 2002:78). In the case of organizations with project selection decisions, such as the FPB, FVA can be used to effectively assess and select an optimal portfolio of projects, or initiatives. FVA is comprised of three major components: (1) assess future challenges and opportunities, (2) conduct a multi-objective decision analysis, and (3) select a portfolio of tasks using optimization techniques (Parnell, 1998).

The first step of the FVA process is to assess future challenges and opportunities. The purpose of this step is to collect data on the target organization detailing "past problems, new opportunities, strategic objectives, goals, evaluation measures, resource constraints, and programmatic constraints" (Parnell, 1998:78). This step can be accomplished in a number of ways. For example, it was accomplished for the Operational Support Office (OSO) through structured interviews with organizational personnel during a study for the US National Reconnaissance Office (Parnell, 1998). Similarly, it was accomplished through structured workgroup meetings with functional experts at the FPB for the creation of a decision making model (Jurk, 2002).

The second step of FVA is to conduct a multi-objective decision analysis (MODA) using value-focused thinking (VFT). There is numerous literature on VFT detailing its effectiveness as a tool for decision makers (e.g., Kirkwood, 1997; Keeney 1994). The VFT process has been used in selecting industry R&D programs (Oral, 1991), evaluating municipal solid waste management alternatives (Shoviak, 2000), and adding insight into decisions regarding resource protection efforts (Dyer, 1999). In 2002, VFT was applied at the FPB to create a project selection model based on the core values and mission of the FPB (Jurk, 2002).

The third step of FVA is to create an optimized portfolio using advanced programming techniques. Using linear programming, a portfolio is created that maximizes the total task value while staying within any resource and programmatic constraints placed upon the organization. This step helps an organization make a decision the best possible decision given their unique set of resource limitations.

The first two steps of FVA were successfully applied to the FPB project selection process in a 2001-2002 research effort (Jurk, 2002); the research in this document builds upon the data and findings of that research. This research, as detailed in Chapter 3, will involve the re-evaluation of step 2, the creation of a MODA using VFT, and the completion of step 3. The original value-focused thinking model is discussed in section 2.4.

2.3 Multi-Criteria Decision-Making Processes

Over the last two decades, there have been a number of tools and processes developed to help organizations and individuals make decision based on a number of competing criteria, or objectives. The two major multi-objective methodologies in use today are the analytic hierarchy process (AHP) and multi-attribute utility theory (MAUT). These are two distinct approaches to multiple criteria decision making that have been proven effective as decision aids in the process of alternative selection (Bard, 1992). This section will attempt to detail the highlights of both processes and offer a conclusion as to why MAUT was chosen for this study.

AHP and MAUT have been compared and contrasted numerous times in recent history (Belton, 1986; Dyer, 1990; Forman, 2001). Those arguing on both sides have agreed that each method is useful in certain situations, but each is flawed as well. A brief description of both methods can lead insight into selecting the correct one for a specific application. AHP was developed in the late 1960's by Thomas Saaty (Forman, 2001). AHP is based around three primary functions: structuring complexity, measurement on a ratio scale, and synthesis (Forman, 2001). Structuring the complexity is designed to

create structural hierarchy divided up by areas of importance and concept similarity (Forman, 2001). Measurement on a ratio scale is required due to the construction of an AHP model. Paired comparisons are performed by the decision maker on the hierarchy factors in order to provide the ratio data needed in the AHP process. Forman's (2001) final function (synthesis) involves conglomerating all of the data in the hierarchy into a concise package. The AHP methodology is able to combine the many separate parts of the problem into a whole. MAUT is a similar methodology but with a vastly different approach. MAUT also involves the creation of hierarchy of values (Keeney, 1992) that serves to deconstruct the focus problem (fundamental objective) into its many sub-elements. Unlike AHP's use of paired comparisons MAUT uses utility functions for the bottom tier values of its hierarchy, which translate the decision maker's risk and value preference into a utility score. By then allowing the decision maker to weight the values of the hierarchy, mathematical functions are used to obtain an overall utility score for the proposed alternatives.

There are several critiques of AHP that have been brought to light since it's inception. The first and perhaps most controversial critique deals with the idea of rank reversal. This is a subject that has been heavily debated on both sides of the issue. Dyer (1990) concluded that AHP should not be used as a process to rank alternatives because the "rankings produced by [the] procedure are arbitrary" (Dyer, 1990: 249). This is primarily due to the phenomenon of rank reversal that is associated with AHP. Rank reversal is the process by which the alternative preferences change when a new non-dominating alternative is added to the AHP alternative set or an existing alternative is deleted. This is primarily seen when an alternative "copy" or close to a copy is added to

the model. Although there have been suggestions to limit this phenomenon (Forman, 1993) as well as new axioms added to AHP (Forman, 2001), it is still possible. However, these methods are often confusing for the decision maker and only valid analytically in special cases (Dyer, 1990; Saaty, 1991). Although a case can be made for acceptable uses of rank reversal (Forman, 2001), in general it is a principle that is not desired.

Another striking difference between AHP and MAUT is the idea of transitivity. Transitivity is a fundamental principle of utility theory, which is illustrated by the following example: If *A* is preferred to *B* and *B* is preferred to *C,* then *A* is preferred to C. AHP does not hold true to the axiom of transitivity. It has been argued that transitivities do exist in the real world (Fishburn, 1991); however, they are yet another complication that can confuse the decision maker and alter the selection results.

The use of paired comparison is one of the primary functions of AHP and through mathematical manipulation helps to produce the alternative driven selection results (Forman, 2001). The scale used to make these paired comparisons is yet another topic of debate surrounding AHP. The 9 point reference scale that a decision maker uses to make paired comparisons in AHP has no "0" reference point (Dyer, 1990). Because of this, it is often difficult to determine the relative differences between the items of comparison. With no explicitly defined reference point, it is left up to each decision maker to determine where the reference point lies which in turn can lead to increased probability of error (Dyer, 1990). It should be pointed out that this scale can be used effectively with proper facilitation (Dyer, 1990; Forman, 2001).

There have been several studies detailing both AHP and MAUT in case study comparisons. Bard (1992), in a Department of Defense study dealing with the logistics

support, examined both methodologies to select alternatives for a cargo-handling problem. The problem dealt with multiple objectives to include risk, performance, time and cost (Bard, 1992). One of the primary conclusions of the study dealt with the aforementioned 9-point ratio scale. It was noted that "each of the decision makers found it difficult to reconcile the fact that expressing a 'weak' preference for one alternative over another they were saying that they preferred it by a factor of three to one" (Bard, 1992: 120). This is a problem inherent to the 9-point ratio scale used in AHP paired comparisons.

In a comparison of AHP to MAUT, Belton (1985) noted several comparisons and differences between the two decision-making processes. Although the comparison was dealing with selecting alternatives off of a shortlist of alternatives, Belton (1985) notes that AHP would not be the most suitable alternative for a larger number of alternatives. In fact, for selection problems involving a large number of alternatives, Belton concludes that "the number of judgments required by the AHP can be somewhat of a burden" (1985: 18). This is primarily due to the alternative based paired comparisons. MAUT, conversely, requires a minimal effort for each additional alternative investigated. In MAUT, the new alternatives need only be scored via the utility functions of the value hierarchy.

2.4 FPB Initiative Selection Using VFT

Value-focused thinking is a method by which alternatives can be ranked according to the value they offer to an organization. VFT is a method of decision-making that has been used and researched extensively (Keeney, 1992; 1994), (Kirkwood, 1997)

and is a process that is firmly rooted in the fundamentals of multi-attribute utility theory. VFT is the method used in previous research to develop the initiative selection model for the FPB (Jurk, 2002). As such, VFT serves as the methodology used for the second step of the FVA process.

Using the VFT model, alternatives (competing potential initiatives) can be scored and ranked based on the level of value they provide to the FPB. Ideally, alternatives with higher scores would be selected because they provide more value to the Air Force. However, when the highest valued alternatives are chosen with no regard to other factors, the solution is often not optimal. For example, three alternatives (A, B, and C) are evaluated in a VFT model and receive the following value scores:

A=0.7 B= 0.5 C=0.4

Consider the following alternative costs:

A=$10,000 B=$4,000 C=$3,000

Now assume the organization is limited to a budget of $10,000. By simply choosing the highest valued alternative, the organization spends its entire budget for a single alternative that provides a value of 0.7. If the organization had used a more advanced technique, such as comparing the benefit received to the alternative cost, they would choose the more optimal solution of alternatives B and C. Alternatives B and C together would cost $3,000 less and provide a value of 0.9 (0.5+0.4). Thus they would receive a greater value at a smaller cost. In order to achieve and determine the optimal solution for such problems, more advanced mathematical techniques are required.

A complete "gold standard" VFT model was created for the FPB (Jurk, 2002) to aid in the selection of force protection initiatives. The FPB VFT hierarchy is defined as a

"gold standard" (Parnell, 2002) because it is based directly on official policy and guidance, in this case Air Force instructions and doctrine, specifically Department of the Air Force AFPD 10-19 and Department of the Air Force AFI 10-1901. The gold standard approach lends credibility to the structure, and creates a defendable position for the alternative chosen. The 10-step process employed by Shoviak (2001) was used at the FPB to help create the VFT hierarchy. Using group problem solving techniques such as affinity diagrams, the hierarchy was constructed via a bottom up approach. Ultimately, the values were grouped into a supporting hierarchy structure which was aligned with the Air Force Instructions of the battlelabs (Department of the Air Force, 1997). For example, the four governing battlelab principles (lean, unique, focused, and innovative) make up the second tier of the FPB hierarchy (Figure 2) and are the foundation for all decisions made regarding initiative selection.

The current VFT model for initiative selection at the FPB is shown in Figures 2-6**.** The VFT model was created by Jurk (2002) and will be briefly explained in the following paragraphs. The top two tiers of the hierarchy are shown in Figure 2. A breakdown of each of the second tier values and their sub-values is also provided. It is a five-tier VFT hierarchy with four primary branches. These four branches have been further categorized into two categories, represented by the existing first tier values, *programmatic* and *impact*. These four branches were generated from the four basic principles of the FPB (Department of the Air Force, 1997).

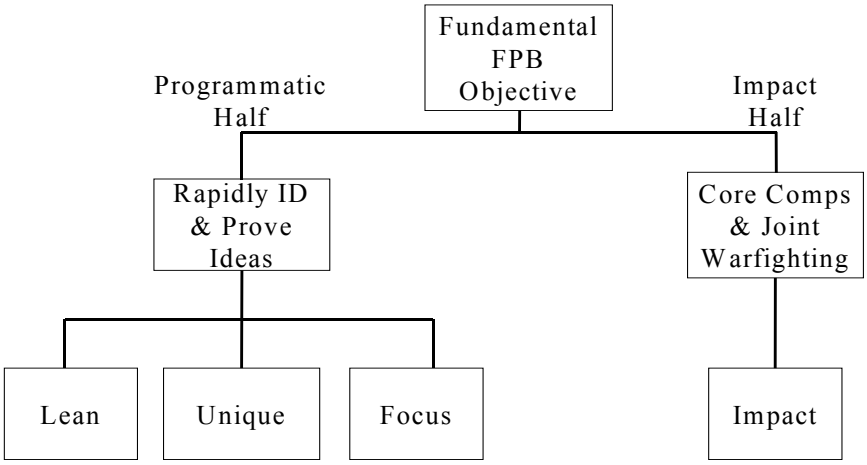


Figure 2. Top Two Tiers- original model

The first branch is labeled *Lean* and is depicted in Figure 3**.** The *Lean* branch is constructed to incorporate the FPB's effective and efficient use of resources. This includes the assignment of personnel to tasks and positions that are most valuable in helping to achieve organizational goals as well as borrowing and leasing equipment and infrastructure instead of purchasing it. Finally, the *Lean* branch encompasses the budgetary impact of an initiative on the FPB.

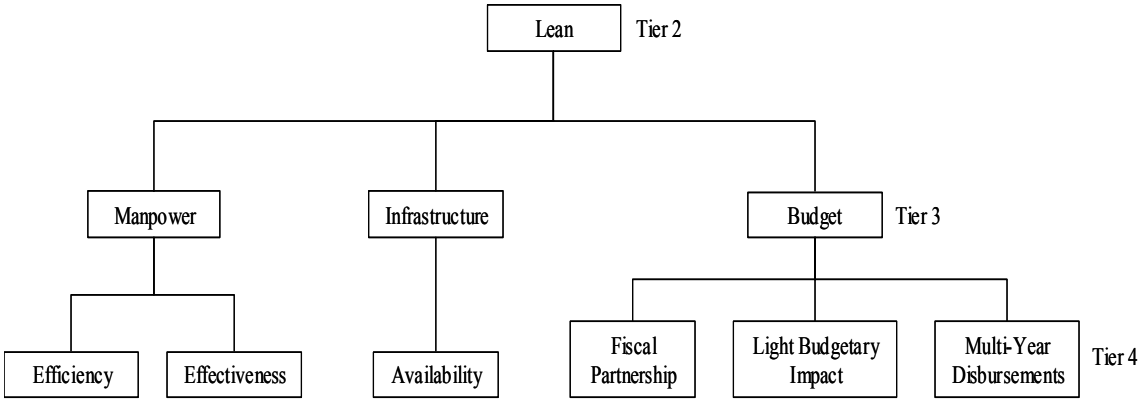


Figure 3. Lean Branch- original model

The second branch is labeled *Unique* and is depicted in Figure 4**.** The *Unique* branch captures the value of an initiative in several ways. First, it captures the level of innovativeness of an initiative. It also measures the degree to which an initiative is associated with the ideas and concepts of force protection. Finally, the *Unique* branch encompasses the degree to which an initiative is being researched by other organizations.

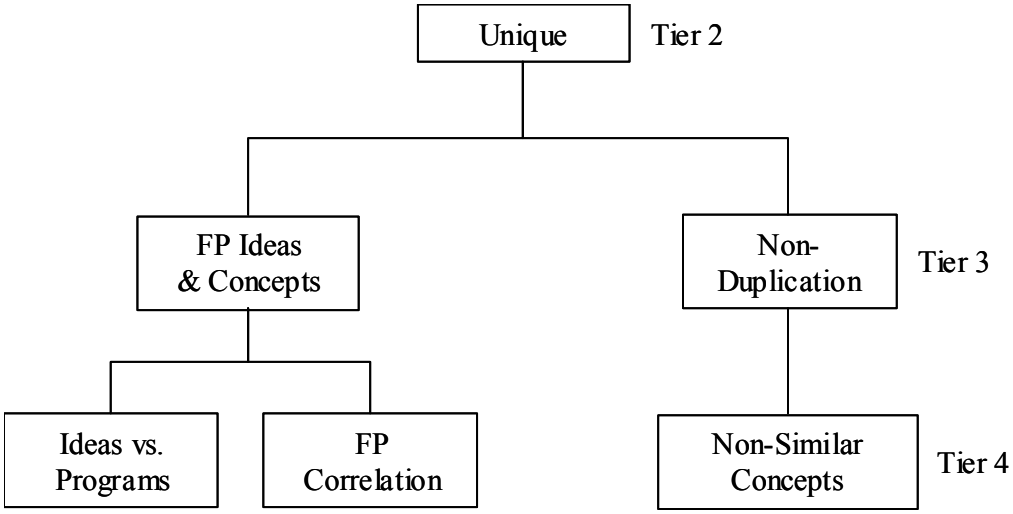


Figure 4. Unique Branch- original model

The third branch is labeled *Focused* and is depicted in Figure 5**.** The *Focused* branch encompasses many factors important to the FPB. First, it contains the urgency and importance of the request. It also captures the various risk associated with an initiative. This includes the potential cost risk, the performance in the field risk and the risk associated with the project timeline. Finally, the *Focused* branch incorporates the value added by an initiative leveraging the resources of others. This includes leveraging existing technology, contracts, and experts around the globe.

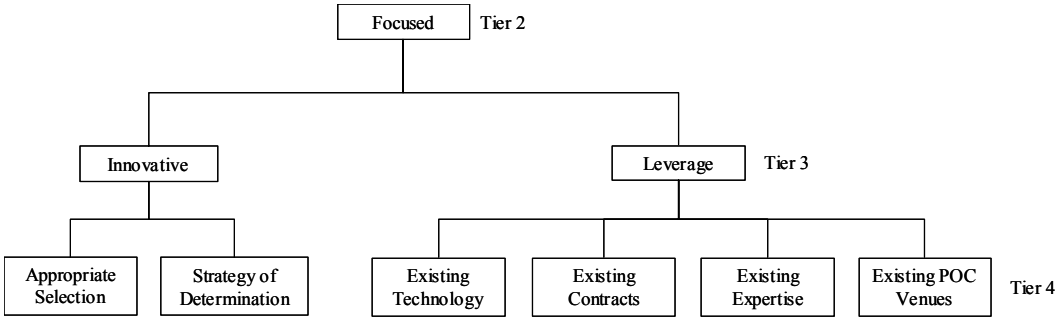


Figure 5. Focused Branch- original model

The fourth branch is labeled *Impact* and is depicted in Figure 6**.** The *Impact* branch is derived from the "innovative" principle of the FPB (Department of the Air Force, 1997). The *Impact* branch includes the value of potential affects an initiative will have on the Air Force. It includes the value of advancing AF core competencies and having a wide spread, long lasting impact. It further incorporates the value of joint involvement of an initiative with the AF's sister services. Finally, it includes the added value of an initiative directly impacting and causing changes to the way the Air Force does business; this is seen by an initiative driving changes to AF doctrine, AF organizational structure, training procedures, acquisitions, and requirements.

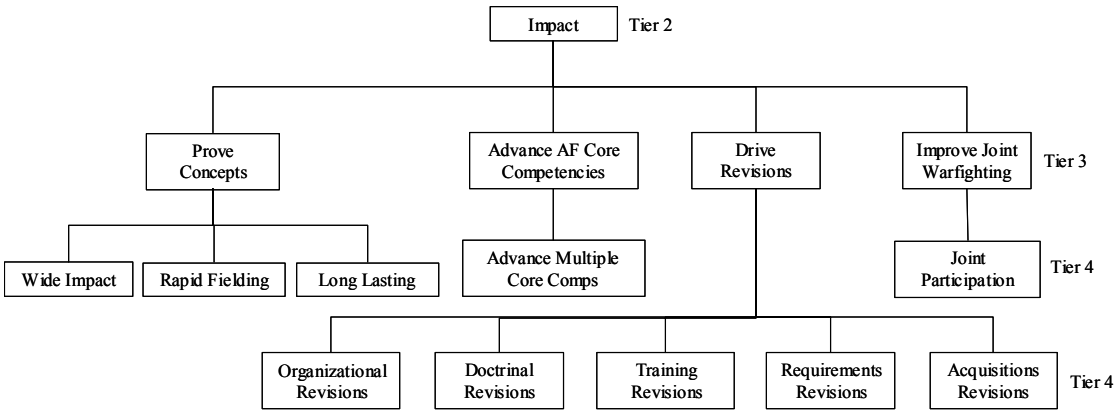


Figure 6. Impact Branch- original model

The VFT hierarchy contains 30 evaluation measures that were derived through working group meetings at the FPB with the action officers (i.e., subject matter experts). Air Force doctrine and instructions guided the development of the hierarchy and all 30 measures. The single dimension value functions (SDVFs) were similarly created by the same action officer working group through a number of meetings (Jurk, 2002). The weighting of the VFT tiers was accomplished by both the FPB commander and the various action officers assigned to work on the initiatives. The commander, the FPB decision maker, weighted the top two tiers and the action officers weighted the remaining three tiers. The FPB commander then approved the entire hierarchy weighting. For a complete list of hierarchy weights see Jurk (2002).

2.5 Linear Programming and Optimization

Linear programming (LP) is a subset of mathematical programming. Specifically, linear programming is a field of study and a technique used to "allocate resources among competing activities in the best possible (i.e., optimal) way" (Hillier, 1990: 29). In 1947, the simplex algorithm was created which vaulted linear programming into new heights, and it is now a widely used and accepted method of optimization (Winston, 1994). Use of the simplex method and LP problem formulation and execution is now a well documented science (Hillier, 1990; Winston, 1994).

In its basic form, linear programming is used in an attempt to find an optimal solution that maximizes or minimizes some objective function subject to a set of linear constraints by changing a set of decision variables (Hillier, 1990). The objective function is a mathematical equation that is a function of the decision variables of a model. For example, a business selling widgets would want to maximize its profit. Therefore, the objective of the company is to make as much profit as possible, so an objective function for profit would be created; for simplicity, we will say *profit=widgets_produced*price (revenue)-widgets_sold*cost (cost).* This equation would represent the objective function. The decision variables are varying factors, which can be changed in order to achieve a new solution to the problem. In the business example, the number of *widgets_sold* is our decision variable, assuming price and cost remain constant. As we change the amount of widgets sold, the value of our objective function changes. Constraints are linear relationships that are forced upon the model. Constraints normally

represent some real-world relationship or resource limitation. In linear programming, there are three main types of constraints: a less than or equal to constraint, a greater than or equal to constraint, or an equal to constraint (Ragsdale, 2001: 19). The constraints in a linear programming problem are what create a mathematical bound to the problem.

With today's modern computer systems, linear programming is even easier and more accessible than ever. Many pieces of software now exist that are capable of solving a set of linear equations and determining an optimal solution based on those equations. One such LP software package, and the software used for the optimization portion of this research effort, is Microsoft Excel Solver (Flystra, 1998: 1). The current version of Excel Solver (Premium Solver version 3.5) includes the linear programming simplex algorithm and is capable of solving complex linear programming problems.

2.6 Project Selection Optimization

When dealing with linear programming problems, one of the first efforts must be towards determining which constraints to use in the model formulation. Doing an extensive literature review revealed no current information pertaining to constraints and objectives directly related to the field of force protection. However, there does exist material dealing with project selection optimization and constraint and objective function development for different project areas outside of the force protection field.

Wiley (1996) provided more details about objective functions and constraints pertaining to multi-project program planning. In his research, Wiley (1996) notes that the constraints of the problem can be summarized as resources (money, people, equipment, etc…), time, and precedence limitations. The first resource constraint is that of budget; the sum of costs of all selected projects must be less than the organizational budget. That is, a project will cost a fixed amount of money to pursue. Wiley's (1996) model also contains a constraint that is defined by the number of personnel-months that it takes to complete the project. Additionally, the model takes into consideration any due-date constraints that are required for the project. These due-dates can then be used to solve the model using a minimum program duration function as the objective function. The final constraint that was introduced into the model was the idea of precedence; this accounted for the fact that some projects must be completed before others could begin. Wiley's (1996) model further took into account the fact that projects could be accelerated and finished early if extra resources were diverted to them; this phenomenon was handled by adding an extra binary variable into each of the constraint functions to represent the acceleration.

Many industries are starting to see the value in portfolio optimization techniques and strategies. The petroleum industry is one such example. Specifically, companies involved in the exploration and production (E&P) market of the petroleum industry have pursued new technologies and systems, which allow integration of portfolio optimization techniques into their businesses (Diggons, 2000). These companies have typically used

simple rank-ordering of potential initiatives based on benefit-cost ratio; this method of selection has resulted in poor return-on-assets for even the top E&P companies (Diggons, 2000). The new portfolio optimization method will provide a selection of initiatives that offer significantly more value to the organization based on that same organization's objectives and constraints (Diggons, 2000). Projects are evaluated based on their asset potential and their level of risk. These projects are then rolled up into a portfolio at the business unit or corporate level. The portfolio optimization process is then run to determine which projects to pursue (Diggons, 2000).

Oral, Kettani, and Lang (1991) developed a method to evaluate and select a research and development (R&D) project using a three-stage approach. The first stage was the R&D project self-evaluation model that involved assigning scores to each project based on resources required and contributions made. The second stage, the R&D project cross-evaluation model, involved creating a matrix which contained the score of each project based on the criteria of all the other projects developed in stage one. Stage three was the R&D project selection model. It involved comparing the projects scores in the cross evaluation matrix created in stage two. Using a mathematical equation, called the level of concordance, projects were compared with each other to see which was the best alternative, based solely on scores. The alternatives were then selected based on the highest level of concordance. Because the only constraint in the model was monetary resources, the highest scored projects were chosen in descending order if the funds were available. This follows the traditional knapsack problem approach to project selection.

Beaujon, Marin, and McDonald (2001) presented an interesting case study involving the balancing and optimization of a portfolio of R&D projects based on data from the General Motors (GM) R&D Center. They developed a selection model that was designed to select a set of projects that best met the strategic objectives of GM while staying within the problem constraints. The primary constraints of the problem were "resource availability, balancing targets, and precedence relationships" (Beaujon, etal, 2001: 22-24).

The resource constraints used in the linear programming model were focused on budget and people available. Each program category type was constrained by a certain budget cap. There was also a maximum amount of additional funding that was allocated to a project from top management. The number of people required for each project was also a resource constraint; every project had an estimated number of people with specific skills required to complete it. The model also contained a constraint on how much additional manpower with these required skills could be hired (Beaujon, 2001). Key to their model was the idea of project balance; the model was designed to create a portfolio that maintained balance between "strategic intent targets" (Beaujon, 2001:21) and "customer-driven/exploratory targets" (Beaujon, 2001:21). The strategic intent targets represents GM's goal of balancing funding and efforts across each of its primary strategic focus areas. The customer-driven/exploratory target is designed to maintain balance between the amount of research projects and developmental projects being pursued.

The precedence constraints were composed of forcing project selection and project interdependence. The forced selection constraint allowed the model to force the selection of any project; this allowed for any long-term commitments to be fulfilled. The interdependence constraint ensured that any projects that were dependant upon the selection of other projects were adequately accounted for (Beaujon, 2001).

There were three primary types of decision variables used in the linear model formulation. The primary decision variable type was whether or not to select a particular project. The secondary decision variables were how many additional resources to allocate; this was represented by the ability of the model to add both additional funding and additional skilled manpower (Baeujon, 2001). At this stage an integer solution to the problem could be produced. However, to provide a truly optimal solution, the use of partial funding for projects was implemented into the model (Baeujon, 2001).

The partial funding model allowed for GM to receive some partial benefit from a project that was not funded to its maximum level. By generating functions of net present value, the variable of primary interest to GM, versus the percentage of project implementation, the model was able to calculate a new benefit level. This was accomplished by the use of inverse transformation techniques on the newly generated functions (Baeujon, 2001). The end result of this project selection model is the creation of a tool that combines the organizational objectives and resource and balancing constraints present with the flexibility of partial project funding and a methodology to allocate additional resources.

2.7 Summary

This chapter has identified past uses of decision analysis techniques used throughout the world to help organizations make decisions. This research will build on the VFT model that was already created for the FPB to help select potential initiatives. Incorporating the future value analysis approach will help validate the existing model and incorporate advanced programming techniques to produce an optimal portfolio of initiatives.

Chapter 3: Methodology

3.0 Overview

The Force Protection Battlelab has the "challenge of identifying innovative force protection ideas and assigning an action officer (AO) to lead a proof of concept to determine whether the identified idea advances Air Force capabilities via core competencies or joint warfighting" (Jurk, 2002: 57). The main problem inherent in this task is selecting the correct portfolio of initiatives from those gathered from the field while staying within the boundaries of the constraints placed upon them. The FPB has created a multi-objective model for indicating the value that a particular initiative provides to the FPB and the Air Force (Jurk, 2002). This model is based on the principles of value-focused thinking.

This model provides the framework necessary for a more fine-tuned methodology to be put into effect for initiative portfolio selection at the FPB. The use of future value analysis will allow the model to be refined and an optimal solution to be presented. This chapter will detail the second and third steps of future value analysis (conducting a multi-objective decision analysis and selecting a portfolio of tasks using optimization techniques) and how they were used to better the FPB initiative selection process.

3.1 Existing VFT Hierarchy

The existing hierarchy is taken from research performed in 2001-2002 (Jurk, 2002). For a full description of the values, measures and single dimension value functions that were not changed as a result of this author's research effort see Jurk

(2002). The following sections of Chapter 3 will detail any changes made to the existing VFT hierarchy and the reasons for those changes.

3.2 Re-evaluating the model

The starting point for the second step of the future value analysis was the reevaluation of the existing VFT hierarchy created during 2001-2002 (Jurk, 2002). Initially, personnel from the FPB were given copies of the VFT hierarchy structure and definitions and were asked to review it for errors. This was conducted during the period from April 2002 to August 2002. Afterward, a working group meeting was setup to discuss the questions and concerns raised during the review. The reevaluation working group meeting was conducted with the FPB division chiefs representing the various specialty areas within the battlelab. A full list of attending personnel is included in Appendix A.

The working group meeting was facilitated by members of the research effort. During the meeting, the group was provided definitions of each of the main branches of the existing VFT hierarchy (Jurk, 2002) and the subsequent definitions of the measures in those branches. Questions and concerns were then raised on areas of the VFT hierarchy that needed to be readdressed, added to, or removed. The following section will document the results of the validation effort.

3.2.1 First Tier Placeholder Values

One of the problems encountered in the original study was the inclusion of this tier. The titles of the two values, *Programmatic Half* and *Impact Half,* proved to be a bias for the

FPB personnel. FPB personnel were reluctant to heavily weight the *Programmatic Half* value because the title was relatively insignificant when compared to *Impact Half.*

In this study, FPB personnel were not asked to weight this tier as the values represented placeholders. It was determined that the four fundamental principles of the battlelab, represented last year's second-tier values, were deemed to be more relevant discerning factors. For this reason, the first-tier values have been removed and the four fundamental battlelab principles have become the new first-tier values coinciding with wording in the FPB's mission statement.

3.2.2 The Lean Branch Issues

There were three main issues raised in regards to the *Lean* branch of the existing value hierarchy. The FPB division chiefs wanted to ensure that the following three issues were either included in the existing VFT hierarchy or added to it: the length of time to complete an initiative, the burden of an initiative's logistic tail, and the cost of an initiative to the FPB. The answers to these issues as well as relevant revisions to the hierarchy are detailed below.

Length of Time to Completion

The question was raised as to whether or not the VFT hierarchy included the value of length of time until initiative completion. Upon review of the hierarchy, this concept is indeed included in the current model. The time that it takes from accepting the initiative proposal to briefing the results and recommendations to the Air Force Requirements Oversight Council (AFROC) is included in the *Estimated time to complete an initiative* measure in the *Lean* branch of the VFT hierarchy (Jurk, 2002). The

probability associated with an initiative exceeding this estimated time to complete is also included in the *Schedule risk* measure in the *Lean* branch of the VFT hierarchy (Jurk, 2002). The time that it takes for the Air Force to recognize a benefit from an initiative after it is successfully proven is also included in the *Estimated time to field* measure in the *Impact* branch of the VFT hierarchy (Jurk, 2002). The existing hierarchy encompassed this area of concern and no changes were made.

Logistics Tail

The next question dealt with the logistics trail of an initiative. Specifically, it was asked if the VFT hierarchy incorporated the degree of difficulty in implementing an initiative based on the logistic tail that came with it (i.e., operation and maintenance costs, training costs, etc…). A review of the VFT hierarchy produced no conclusive inclusion of this factor. Therefore, a new measure and single dimension value function (SDVF) was created as detailed later in this chapter.

Percentage Cost vs. Fixed Cost

The final issue raised regarding the *Lean* branch of the VFT hierarchy was whether the percentage cost bore by others should be changed to a monetary value instead of a percentage value. Upon review of the battlelab principle of *leanness,* it was decided that the percentage measure better captures the value of being "lean" by leveraging other agencies and organizations and their resources. The FPB is, however, concerned with selecting the most optimal set of initiatives; therefore, it was decided to include this in the optimization portion of the future value analysis effort using budget as

a constraint. The existing hierarchy encompassed this area of concern and no changes were made.

3.2.3 The Unique Branch Issues

There were two main issues raised in regards to the *Unique* branch of the existing value hierarchy. The FPB division chiefs wanted to ensure that the following two issues were either included in the existing VFT hierarchy or added to it: the quantum leap factor and the validity of the existing non-duplication values. The answers to these issues as well as relevant revisions to the hierarchy are detailed below.

Quantum Leap Factor

The first concern of the working group on the *Unique* branch was that the VFT hierarchy did not include the value of selecting an initiative that provided a "quantum leap" for force protection ideas in the Air Force. It was felt that an initiative should receive some value for being on the cutting edge of technology or being supremely innovative. While the VFT hierarchy does take into account estimated changes to Air Force organizational structure, doctrine, training, requirements, and acquisitions, this "quantum leap" factor is not present. Therefore, a new measure and SDVF was created as detailed later in this chapter.

Non-Duplication Validity

The question was also raised as to the validity of the non-duplication value. Specifically, it was felt that duplication of effort could be valid if the FPB was pursuing a short-term fix to some problem, while another agency pursued a long-term fix. In the

current model, such an initiative would receive no value for this useful short-term fix in both the *longevity* measure and *non-similar concepts* measure (Jurk, 2002). Adding a measure to capture the value of a short-term fix in this situation would have the effect of canceling out the existing *longevity* and *non-similar concepts* measures. This would violate one of the founding principles of a VFT model, that of nonredundancy (Kirkwood, 1997), because this measure would not be independent of *longevity* and *non-similar concepts*. When a case arises where a short-term solution is deemed advisable, it is an exception to the general rule. Such a case should be handled in post-analysis by the decision maker. Making changes to the current hierarchy to satisfy this exception would violate the model principles. The existing hierarchy encompassed this area of concern and no changes were made.

3.2.4 The Focused Branch Issues

There were six main issues raised in regards to the *Focused* branch of the existing value hierarchy. The FPB division chiefs wanted to ensure that the following concepts were either included in the existing VFT hierarchy or added to it: the level of request, multiple requesting agencies, sponsorship, transition, sponsorship availability, and leveraging multiple technologies. The answers to these issues as well as relevant revisions to the hierarchy are detailed below.

Level of Request

The first concern raised was the desire for more detail in the *Level of request* measure. It was the working group's opinion that the duty status of the requesting unit

should be evaluated (i.e., active duty, reserve, or national guard). A new measure and SDVF was created as detailed in the next section of this research document.

It was further felt that additional agencies (correspondence, 2002) should be added to the single dimension value function (SDVF) for the existing *level of request* measure. However, a review of the SDVF for *level of request* indicated that these agencies were covered in the existing function. A review of the existing SDVF was conducted in the third working group meeting and the existing SDVF was changed as documented in the next section.

Multiple Requesting Agencies

The issue of multiple requesting agencies was brought up because it is not currently covered in the existing model. It was asked whether more value is added to an initiative when multiple agencies request it. After a review of the existing VFT hierarchy, it was determined that the measure *level of request* captures the required value. Currently, if multiple agencies submit a request, the highest one is used to score the initiative. Any further importance placed on this issue should be covered in a post analysis phase. The existing hierarchy encompassed this area of concern and no changes were made.

Sponsorship

A key issue brought up during the workgroup meeting is the idea of sponsorship. This is a broad area and the group was unclear on whether it was fully covered in the VFT model. Specifically, there was a desire to include the transition of an initiative to a sponsor as well as including the value of having a sponsor for sustainment of an

initiative. Finally, there was a desire to include value for sponsorship being available in the VFT hierarchy.

Sponsorship: Transition

The transition of an initiative to a sponsor is not currently included in the VFT hierarchy. However, the inclusion can be combined with the logistics tail concerns addressed in Section 3.2.1. The logistics tail takes into account the need for sponsorship during the initial transition into the field and well as sponsorship during the sustainment phase (i.e., long-term sponsorship). To account for this and the logistics tail, changes were made to the hierarchy as noted later in this chapter.

Sponsorship: Sponsorship Availability

The VFT hierarchy does not currently include the value added by having a sponsor available for fielding the initiative. Currently, value is only given for sponsorship during the "proof of concept" phase. This can be seen in the *% initiative cost bore by others* measure of the *Lean* branch and to a lesser extent in the *degree of leveraging existing technology*, the *degree of leveraging existing contracts*, the *degree of leveraging existing expertise*, and the *degree of leveraging existing POC venues* (Jurk, 2002). All of these measures take into account value added from external agencies towards the completion of the "proof of concept" of the initiative and therefore act as proxies for the desired value of sponsorship. The existing hierarchy encompassed this area of concern and no changes were made.

Leveraging Multiple Technologies

It was also felt that initiatives leveraging multiple technologies was not accounted for in the existing VFT hierarchy. Upon review of the hierarchy, this was confirmed. The addition of a measure to the existing *technology* value of the *Focused* branch provides the desired value. Therefore, a new measure and SDVF was created as detailed later in this chapter.

3.2.5 The Impact Branch Issues

There were five main issues raised in regards to the Impact Branch of the existing value hierarchy. The FPB division chiefs wanted to ensure that the following issues were either included in the existing VFT hierarchy or added to it: drive revisions, homeland defense, government agencies supported, mission type supported, and continental US (CONUS) versus overseas support. The answers to these issues as well as relevant revisions to the hierarchy are detailed below.

Drive Revisions

In the *drive revisions* value, the question was raised as to whether the wording should be changed from "Air Force" to "DoD", thus implying that any revisions to other services organizational structure, doctrine, training, requirements, or acquisitions was perceived as adding value to an initiative. It was agreed that this was not in line with the FPB principles and mission, which explicitly focuses on providing "the Air Force opportunities to reach investment decisions more quickly and organize, train, equip, and program, more efficiently" (Department of the Air Force, 1997:2). The existing hierarchy encompassed this area of concern and no changes were made.

Homeland Defense

It was also asked if the VFT hierarchy took into account an initiative's impact on homeland defense, which has become increasingly more valuable in the last year. The measure *Wide Impact* addresses how far-reaching an initiative is and the *Advanced AF Core Competencies* measure indicates the number of AF core competencies an initiative helps to further; both of these measures could possibly indirectly measure an initiative's impact on homeland defense. However, to capture the added value of an initiative adding directly to the homeland defense effort requires the addition of a new measure. Therefore, a new measure and SDVF was created as detailed later in this chapter.

Government Agencies Supported

It was also desired that credit be given to an initiative for not only co-involvement with sister services, currently covered in the *joint involvement* measure of the *Impact* branch, but also for involvement with other government agencies (i.e., Federal Bureau of Investigations, Central Intelligence Agency, etc…). This is accomplished by changing the title and definition of the *joint involvement* measure as seen later in this chapter.

Mission Type Supported

The issue of giving credit for the type of mission (e.g., peacekeeping, war-time, anti-terrorism, etc…) an initiative supported was also raised during the working group meeting. The existing value hierarchy does not contain this. This issue will be addressed in the optimization phase of the future value analysis model. Essentially, the decision maker can decide which mission type to support and the best initiative can be selected

from the pool of initiatives supporting the selected mission type. This selection would be accomplished during a post-analysis phase.

CONUS vs. Overseas Support

The issue of whether an initiative should receive credit based on whether it provides impact to a CONUS or overseas location was also asked. There is no direct measure to reflect this value in the existing VFT hierarchy. However, the *urgency* measure in the *Focused* branch indirectly captures the value. An initiative would receive a higher score on the *urgency* measure if it is generated from an overseas base in need rather than a CONUS location that has a lower threat potential. The existing hierarchy encompassed this area of concern and no changes were made.

3.3 New VFT Hierarchy Structure

During the workgroup meeting and subsequent correspondence with FPB personnel, the original VFT model was revised and validated to ensure the areas of concern were sufficiently included. The next section will detail the revised VFT hierarchy and define any material added and changed in the original model.

3.3.1 Overview

After the evaluation of the original model was complete, the hierarchy structure was changed to address the areas of concern. Figures 7 through 11 show the new VFT hierarchy with any values or measures that were changed or added highlighted. This section will detail and describe the changes that were made to the original VFT hierarchy.

For a full description and definition of the values and measures that were not changed, see Jurk (2002).

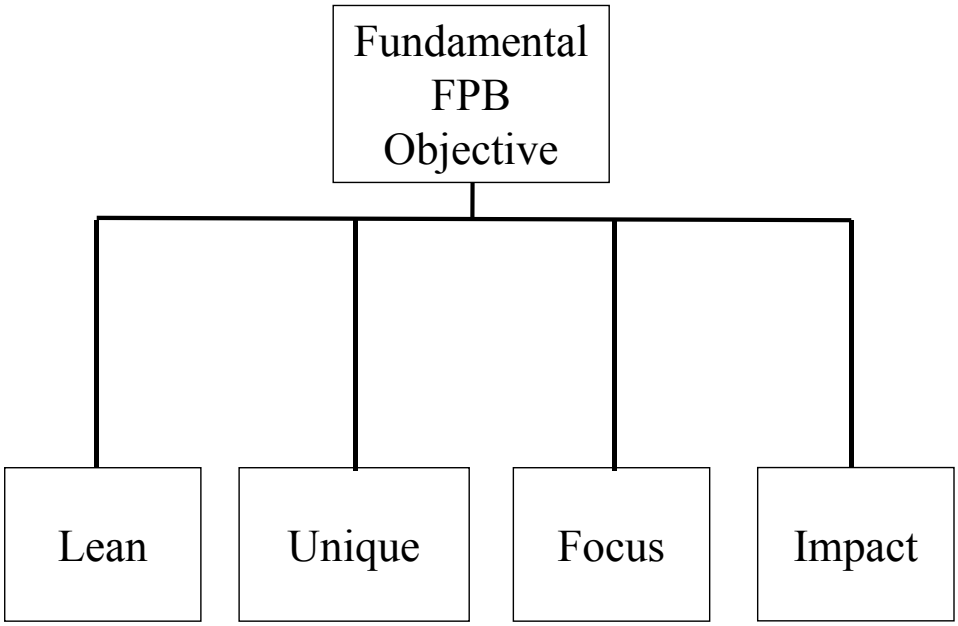


Figure 7. Fundamental Objective and Top Tier

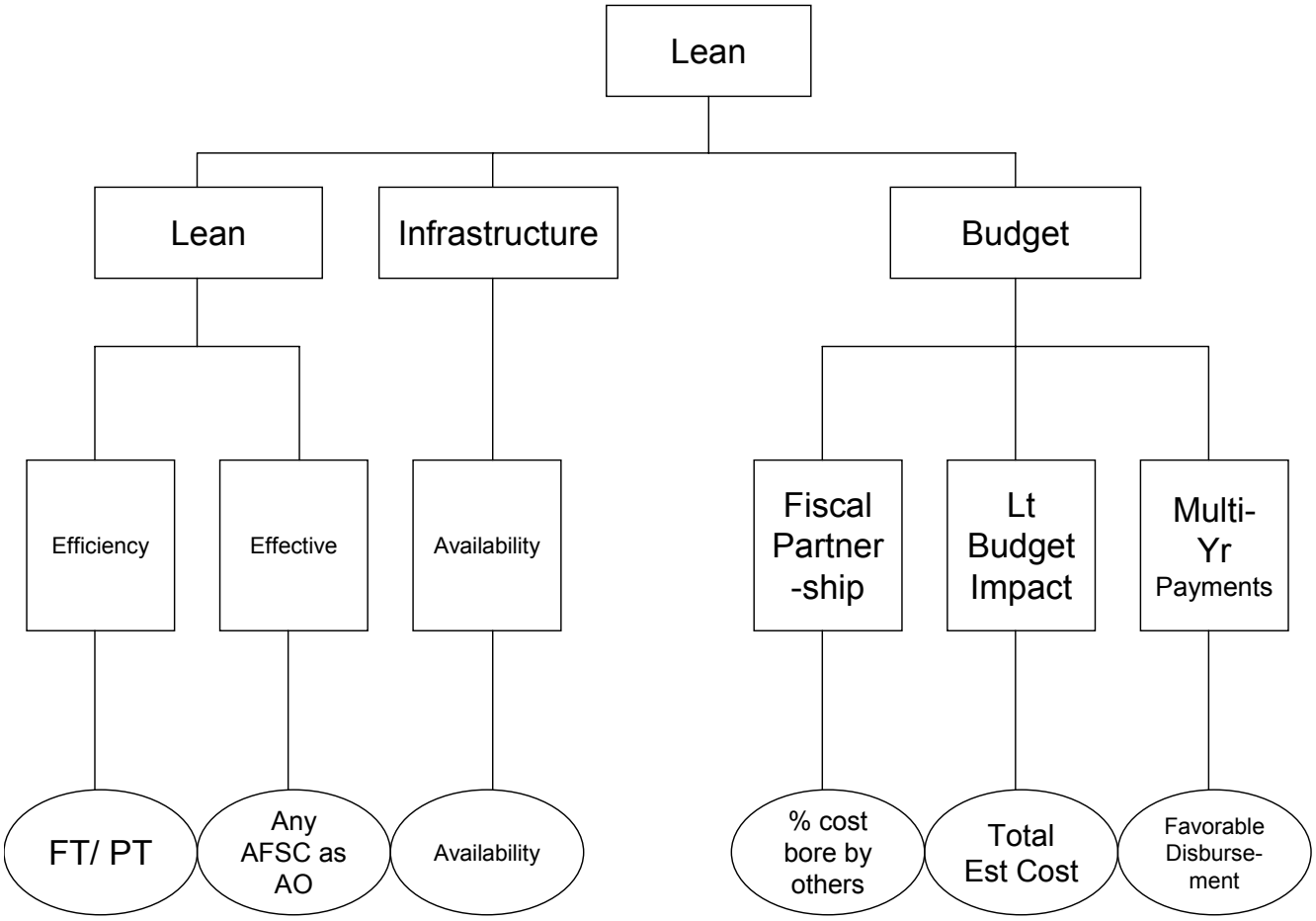


Figure 8. Lean Branch of Model

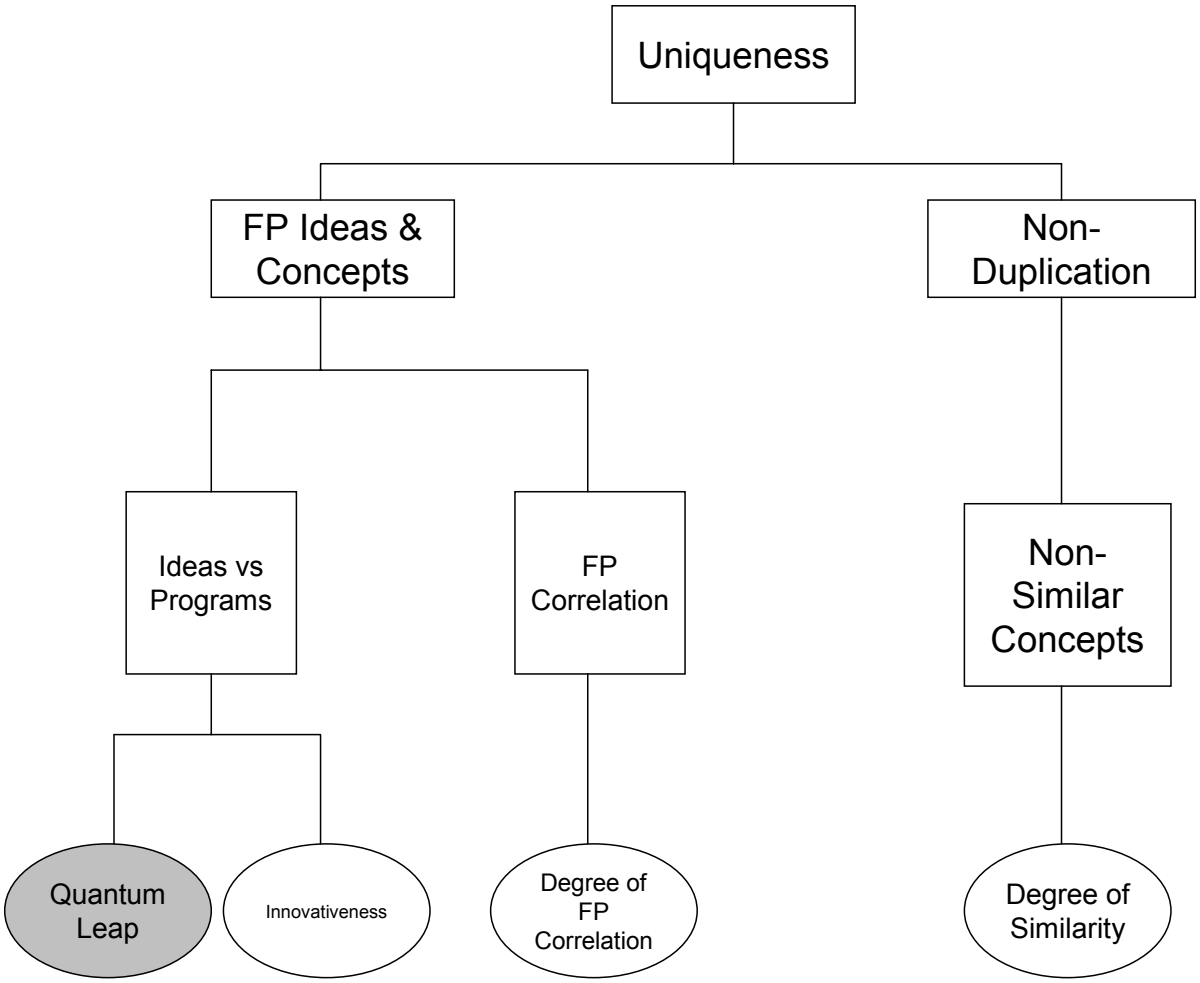


Figure 9. Unique Branch of Model

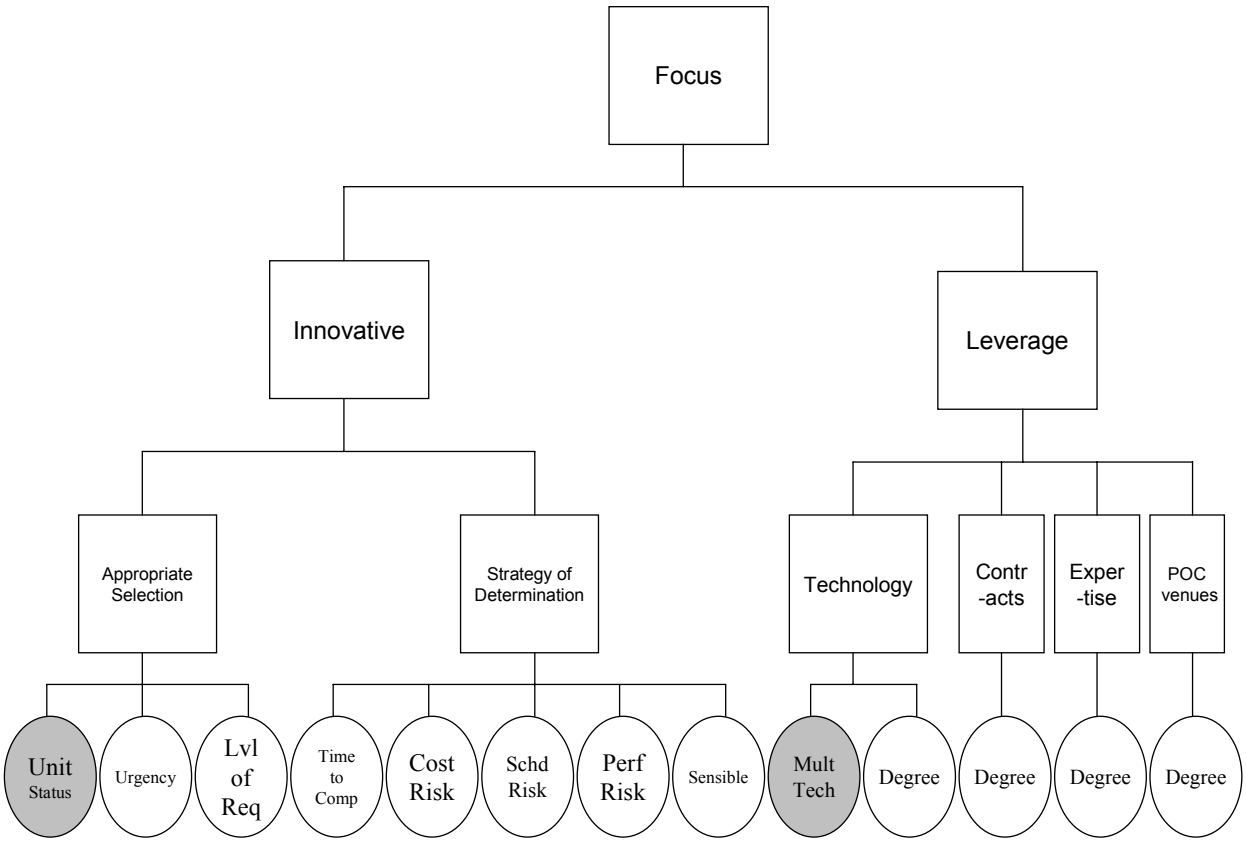


Figure 10. Focused Branch of Model

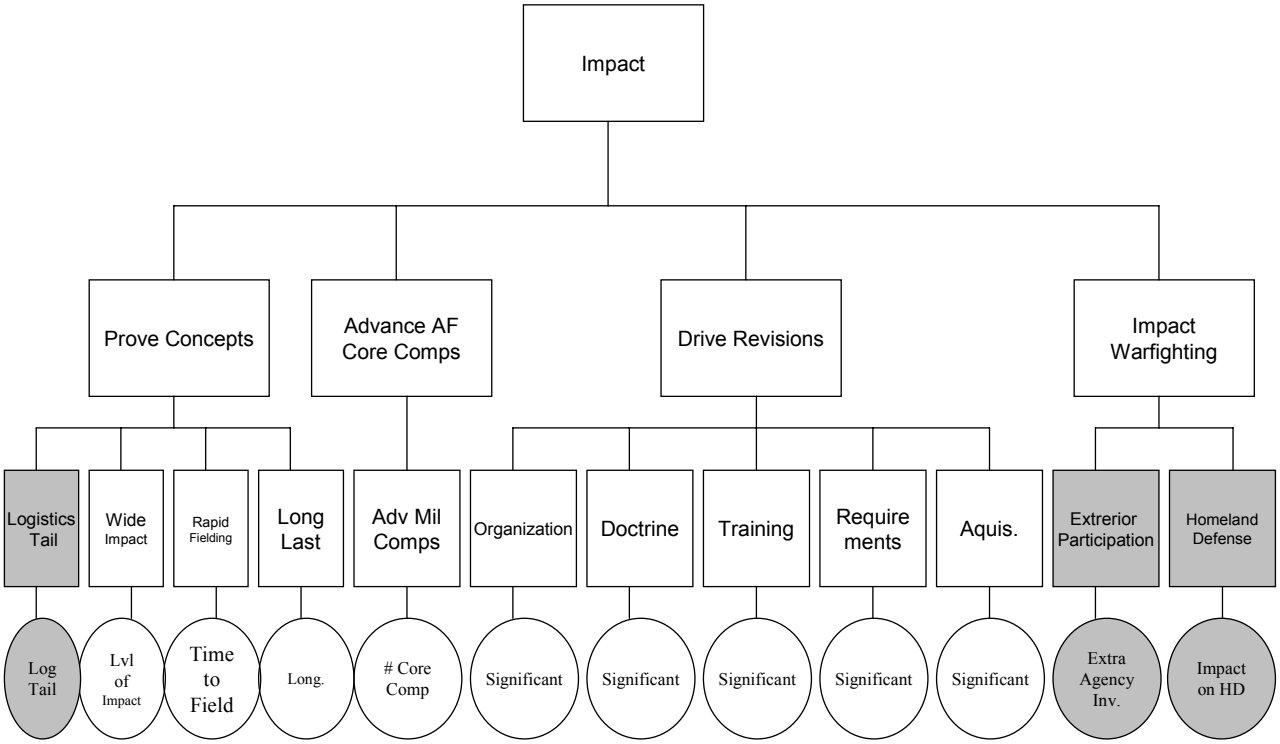


Figure 11. Impact Branch of Model

3.3.2 New Measures Created

Table 1 summarizes the new measures that have been created or changed in each of the four branches. It also details each of the new measure's upper and lower bounds. Table 2 provides full definitions for the new and changed measures.

Table 1. New Measures with Bounds

VFT Branch	Fourth-Tier Hierarchy Value	Associated Measure	Lower Bound	Upper Bound	New Measure/ Changed
Uniqueness	Ideas vs. Programs	Quantum Leap	Readily Available /Used	Just in Theory	New
Focus	Logistics Tail	Logistics Tail	Heavy	Minimal to None	New
Focus	Appropriate Selection	Unit Status	None	Active Duty	New
Focus	"Leverage" Technology	Multiple Technologies	No	Yes	New
Impact	Exterior Participation	Extra Agency Involvement	No	Yes	Changed
Impact	Homeland Defense	Impact on Homeland Defense	Minimal to None	Exclusively HD	New

Table 2. New Measure Definitions

Measure	Definition
Logistics Tail	The extra costs, equipment, personnel and time involved with an initiative after it is fielded (i.e. operation and maintenance costs, training costs and time…).
Quantum Leap	How close to the cutting edge of technology or how innovative an initiative is.
Unit Status	Whether a submitting unit is Active Duty, Reserve, or National Guard.
Multiple Technologies	Whether an initiative is designed to leverage a single or multiple types of technologies.
Extra Agency Involvement	Proxy measure that indicates the potential for future improvement of joint warfighting. It considers the probability of cooperation from other DoD services and governmental agencies with the execution of the initiative.
Impact on Homeland Defense	The potential a successfully proven initiative has to significantly affect Homeland Defense operations or activities.

3.4 Single Dimension Value Functions

Each measure requires an SDVF to convert its x-axis units to units of value. To keep in tune with the existing VFT model, each SDVF was created so it is always monotonically increasing. The SDVFs for the new and changed measures were created by FPB personnel during the third working group meeting (9 October 2002). As with the initial model creation, "the technique used to construct the SDVFs relied on the experience and judgment of FPB personnel" (Jurk, 2002).

3.4.1 SDFV for Logistics Tail

The SDVF in Figure 12 translates the score a potential initiative receives for the measure *Logistics Tail* into a unit of value between zero and one. The FPB is mandated to use its budget in the most effective manner possible; therefore, they are benefited more by choosing initiatives with close to no logistics tail over those with average or heavy logistics tail. Table 3 provides the definitions for the x-axis categories of the SDVF. Therefore, *minimal to none* is the most preferred category and *heavy* is the least preferred.

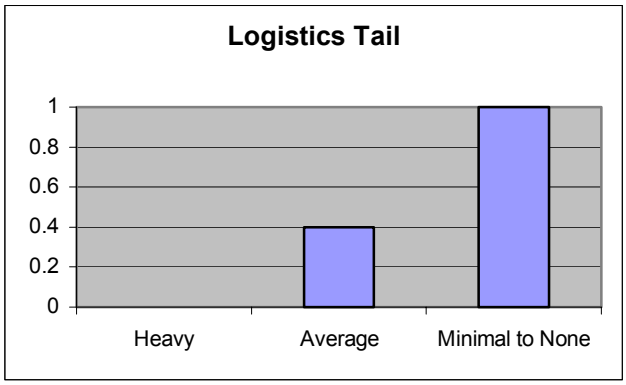


Figure 12. Logistics Tail SDVF

Table 3. Logistics Tail SDVF Definitions

Category	Definition
Heavy	Above average cost or time associated with the initiative during its transition into the field and its subsequent field use.
Average	Cost or time associated with the initiative during its transition into the field and its subsequent field use is in line with the majority of other initiatives.
Minimal to None	There is practically no cost, time, or resource requirements for the transition and sustainment of this initiative.

3.4.2 SDFV for Quantum Leap

The SDVF in Figure 13 translates the score a potential initiative receives for the measure *Quantum Leap* into a unit of value between zero and one. The quantum leap factor is designed to capture great leaps in innovative thinking; thus, there is only a gain of 0.2 value for an initiative using mostly developed ideas over an initiative that is not innovative at all. Table 4 provides the definitions for the x-axis categories of the SDVF. Therefore, *Just in Theory* is the most preferred category and *Readily available/used* is the least preferred.

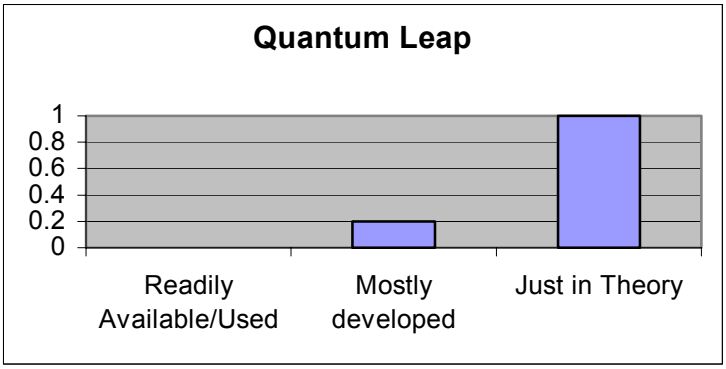


Figure 13. Quantum Leap SDVA

Table 4. Quantum Leap SDVF Definitions

Category	Definition
Readily Available/Used	The ideas and concepts presented in the initiative are already being used or are common practices.
Mostly Developed	There are currently projects in their infancies or prototypes being experimented that demonstrate the concepts seen in the initiative.
Just in Theory	The idea is so far on the cutting edge of thinking that this is the first time it has ever been attempted or researched.

3.4.3 SDFV for Unit Status

The SDVF in Figure 14 translates the score a potential initiative receives for the measure *Unit Status* into a unit of value between zero and one. The FPB sees a significant value from a benefit to any service unit with a slight favor given to Reserve units over National Guard units. *Active duty* is the most preferred category and *none* is the least preferred. Table 5 provides the definitions for the x-axis categories of the SDVF.

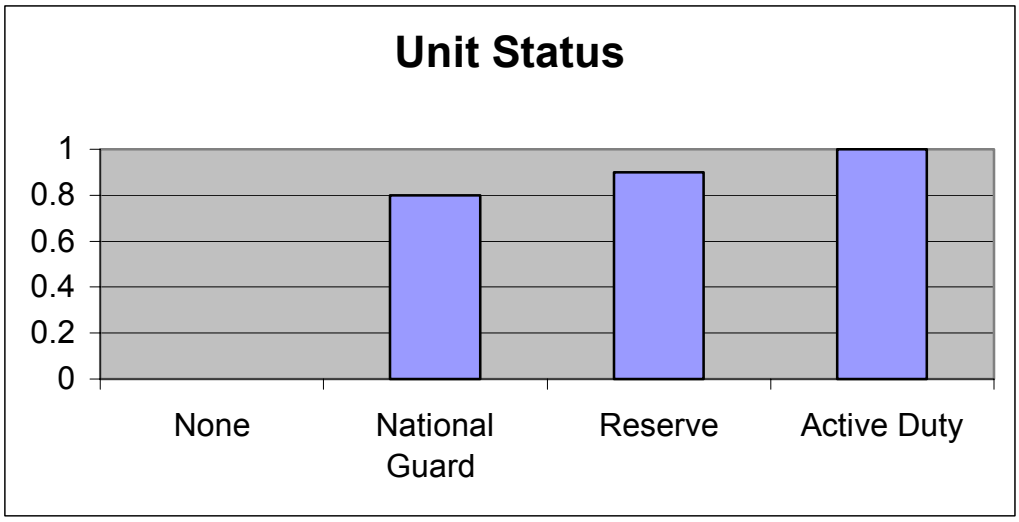


Figure 14. Unit Status SDVF

Table 5. Unit Status SDVF Definitions

Category	Definition
None	The unit impacted (customer unit) belongs to none of the service organizations.
National Guard	The unit impacted (customer unit) belongs to one of the service's National Guard.
Reserve	The unit impacted (customer unit) belongs to one of the service's Reserve forces.
Active Duty	The unit impacted (customer unit) belongs to one of the active duty services.

3.4.4 SDFV for Multiple Technologies

The SDVF in Figure 15 translates the score a potential initiative receives for the measure *Multiple Technologies* into a unit of value between zero and one. Therefore, *yes* is the most preferred category and *no* is the least preferred. Table 6 provides the definitions for the x-axis categories of the SDVF.

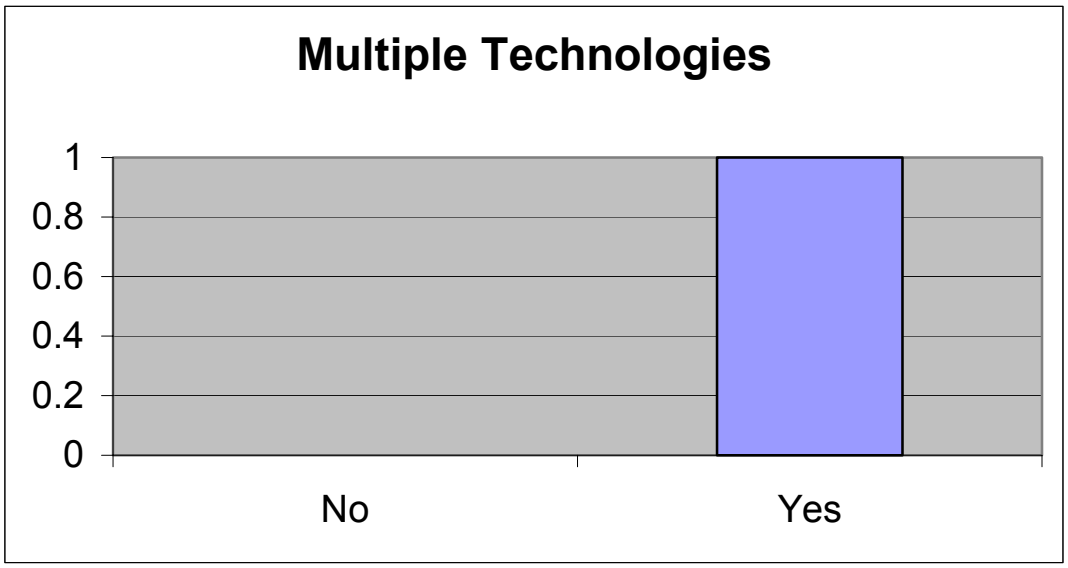


Figure 15. Multiple Technologies SDVF

Table 6. Multiple Technologies SDVF Definitions

Category	Definition
No	The initiative does not combine the leveraging of multiple technologies.
Yes	The initiative does combine the leveraging of more than one technology.

3.4.5 SDFV for Extra Agency Involvement

The SDVF in Figure 16 translates the score a potential initiative receives for the measure *Extra Agency Involvement* into a unit of value between zero and one. Therefore, *yes* is the most preferred category and *no* is the least preferred. The SDVF was not changed from the SDVF created for the *Joint Involvement* SDVF in the 2002 study (Jurk, 2002) because this measure was simply a change in wording from *Joint Involvement* to *Extra-Agency Involvement* to capture the value of helping agencies other than sister services. Table 7 provides the definitions for the x-axis categories of the SDVF.

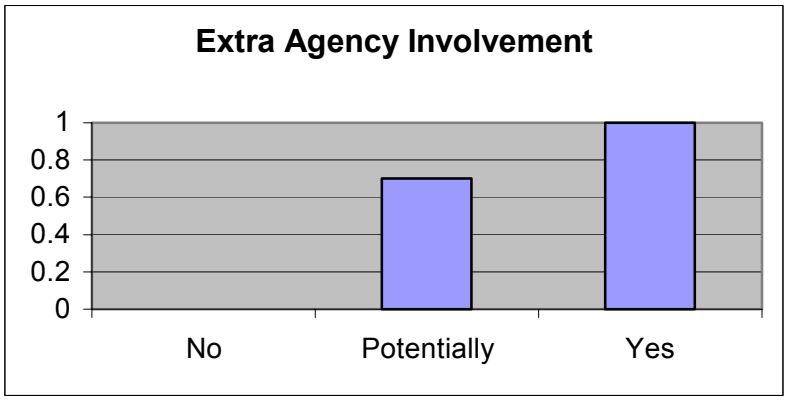


Figure 16. Extra Agency Involvement SDVF

Table 7. Extra Agency Involvement SDVF Definitions

Category	Definition
No	There is absolutely no potential for extra agency involvement with this initiative.
Potentially	There is reasonable chance there will be extra agency involvement with this initiative.
Yes	There is definite extra agency involvement (known from the start) with this initiative.

3.4.6 SDFV for Impact on Homeland Defense

The SDVF in Figure 17 translates the score a potential initiative receives for the measure *Impact on Homeland Defense (HD)* into a unit of value between zero and one. The FPB equally values a jump from minimal HD impact to moderate HD impact with a jump from moderate HD impact to Exclusively impacting HD. Therefore, *Exclusively Homeland Defense (HD)* is the most preferred category and *minimal to none* is the least preferred. Table 8 provides the definitions for the x-axis categories of the SDVF.

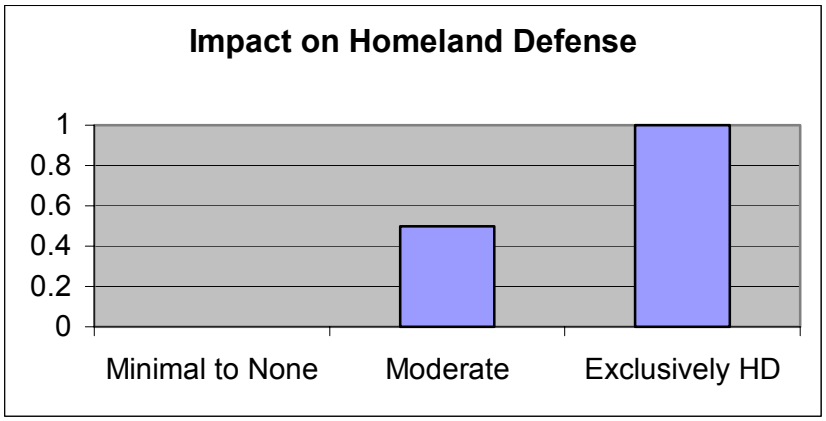


Figure 17. Impact on Homeland Defense SDVF

Table 8. Impact on Homeland Defense SDVF Definitions

Category	Definition
Minimal to None	There is almost no potential for this initiative to impact homeland defense.
Moderate	There is a reasonable chance for this initiative to impact homeland defense.
Exclusively Homeland Defense	All of the impact of this initiative will be on homeland defense.

3.5 Weighting the New VFT Hierarchy

After the SDVFs were created for the new measures, the next step was to weight the revised VFT model. By weighting each of the values in the hierarchy, the FPB was able to differentiate the relative importance of those values. The 1st tier of the hierarchy was weighted by the FPB commander. As a final decision maker in the initiative selection process his values should be reflected in the hierarchy weighting. The rest of the hierarchy was weighted by the battlelab division chiefs (subject matter experts and senior level members in the decision making process) in a working group atmosphere.

The weighting was accomplished in a top-down approach. The entire hierarchy was weighted using the direct weighting technique. The hierarchy was weighted locally, meaning that values in each tier of each branch were weighted with respective to the other values in their tier and branch. The FPB division chiefs were not shown the previous hierarchy weighting from Jurk (2002) in an effort to not bias their new weights. The resulting local and global weights for the FPB value hierarchy are described in the remainder of this section.

3.5.1 First-Tier Weights

The values comprising the first-tier of the hierarchy are the four fundamental principles of the FPB (Department of the Air Force, 1997), with the "innovative" principle being renamed to "impact" taken from AFI 10-1901 (Jurk, 2002). The commander of the battlelab placed a 15 percent emphasis (i.e., weight of importance = 0.15 out of 1.0) on the second-tier value *Lean*, a 25 percent emphasis on the value *Unique*, a 25 percent emphasis on the value *Focused,* and a 35 percent emphasis on the

value *Impact*. The following sections will discuss the weights assigned to the values within each of the four branches of the VFT hierarchy.

3.5.2 Weights for the Lean Branch Values

The value *Lean* was assigned 15 percent of the total weight of importance (i.e., 100 percent) distributed between the four first-tier values. The global weight for *Lean* is also 0.15. This branch, as with all four branches, was weighted by the FPB division chiefs and approved by the commander. The relatively small amount of emphasis placed on the value *Lean* reflects the belief that keeping within the streamlined organizational structure, budget, and workspace is not a major factor in determining which initiatives to select.

The three values that comprise the second-tier of the value *Lean* are *Manpower*, *Infrastructure*, and *Budget*, each having local weights of 0.4, 0.2, and 0.4, respectively. The global weights are 0.06, 0.03, and 0.06, respectively. The FPB personnel felt that *Manpower* and *Budget* deserved the highest weight of importance because without efficient and effective manpower and monetary resources, they are unable to execute an initiative. The FPB personnel placed the least emphasis on *Infrastructure* because they are confident that the infrastructure required will almost always be available and thus is not comparatively important (Jurk, 2002).

3.5.2.1 Weights for the Values Under *Manpower*

The FPB personnel felt *Efficiency* and *Effectiveness* were close in relative importance; therefore, the local weights are 0.4 and 0.6, respectively. The global weights are 0.024 and 0.036, respectively. They acknowledged that having the potential of

allowing anyone to work on an initiative was slightly more important than whether the potential initiative would require a full-time AO. This is due to the fact that "the spectrum of potential initiatives is great and an AO's ability to be a generalist is more important than their career field specialty" (Jurk, 2002:168).

3.5.2.2 Weights for the Values Under *Infrastructure*

The only value under *Infrastructure* is *Availability*. Therefore, it receives 100 percent of the emphasis, its local weight is 1.0, and its global weight is 0.03.

3.5.2.3 Weights for the Values Under *Budget*

The FPB personnel assigned the values comprising *Budget* (*Fiscal Partnership*, *Light Budgetary Impact*, and *Multi-Year Disbursements*) local weightings of 0.4, 0.4, and 0.2, respectively. The global weights are therefore, 0.024, 0.024, and 0.012, respectively. The overall estimated cost of the initiative and the ability to share the burden with other organizations were the most important elements of the budget to FPB personnel because they felt that this would allow them pursue more initiatives and help them stay "lean." The lower weighting of *Multi-year disbursements* indicates that spreading the cost of an initiative over multiple fiscal years is more of a desire than a necessity (Jurk, 2002).

3.5.2.4 Weights for the Measures Under the *Lean* Branch

Each third-tier value within the *Lean* branch has only one measure associated with it. Therefore, each measure receives a local weight of 1.0. The global weight for each measure is shown in Table 9**.**

Table 9. Global Weights for *Lean* Branch Measures

***Lean* Branch Measures**	**Global Weight**
Full or Part-time	0.024
Any AFSC as AO	0.036
Infrastructure Location	0.03
% Initiative Cost Bore by Others	0.024
Total Estimated Initiative Cost	0.024
Favorability of Disbursement	0.012

3.5.3 Weights for the Unique Branch Values

The value *Unique* was assigned 25 percent of the total weight of importance distributed between the four first-tier values. The global weight for *Unique* is also 0.25. This branch, as with all four branches, was weighted by the FPB division chiefs and approved by the commander. The moderate amount of local emphasis (i.e., 25 percent) given to *Unique* reflects the belief of the FPB commander that initiatives should be credited for how closely they tie into force protection ideas. It also indicates the commander's desire to stay innovative and not duplicate research and proof-of-concept efforts being conducted by other organizations. The commander's beliefs are further reflected in the weights of importance assigned by the division chiefs to the second and third-tier values and the fourth-tier measures within the *Unique* branch.

The two values that comprise the second tier of the value *Unique* are *FP Ideas & Concepts* and *Non-Duplication*, each having local weights of 0.8 and 0.2, respectively.

The global weights are 0.2 and 0.05, respectively. The FPB personnel felt that *FP Ideas & Concepts* deserved a higher weight of importance due to their intended focus area (force protection) as directed by AFPD 10-19 (Department of the Air Force, 1997:1) (Jurk, 2002).

3.5.3.1 Weights for the Values Under *FP Ideas & Concepts*

The FPB personnel felt the value *FP Correlation* was slightly more important than *Ideas vs. Programs*; therefore, the local weights are 0.6 and 0.4, respectively. The global weights are 0.12 and 0.08, respectively. This difference in weighting was primarily due to the aforementioned directive of the FPB to pursue force protection related issues.

3.5.3.2 Weights for the Values Under *Non-Duplication*

To achieve visual symmetry at the fourth tier and allow easy understanding of the hierarchical structure, the only value under *Non-Duplication* is *Non-Similar Concepts*. Therefore, it receives 100 percent of the emphasis, its local weight is 1.0, and its global weight is 0.05.

3.5.3.3 Weights for the Measures Under the *Unique* Branch

With the exception of *Ideas vs. Programs*, each third-tier value within the *Unique* branch has only one measure associated with it. Therefore, each of these measures receives a local weight of 1.0. The global weight for each measure is shown in Table 10. For the value *Ideas vs. Programs*, the FPB personnel felt that each of the two measures

(Quantum Leap and Innovativeness) were equally important. Therefore, each measure received a local weight of 0.5 and their global weights are annotated in Table 10.

Table 10. Global Weights for *Unique* Branch Measures

***Unique* Branch Measures**	**Global Weight**
Quantum Leap	0.04
Innovativeness	0.04
Degree of FP Correlation	0.12
Degree of Similarity	0.05

3.5.4 Weights for the Focused Branch Values

The value *Focused* was assigned 25 percent of the total weight of importance distributed between the four first-tier values. The global weight for *Focused* is also 0.25. This branch, as with all four branches, were weighted by the FPB division chiefs and approved by the commander. The moderate amount of local emphasis (i.e., 25 percent) given to *Focused* reflects the belief of the FPB commander that "the proper selection and proof of concept execution, along with the ability to leverage existing resources (i.e., technology, contracts, expertise, and POC venues), is vitally important to the successful achievement of their mission statement" (Jurk, 2002:156). The commander's beliefs are further reflected in the weights of importance assigned by the division chiefs to the second and third-tier values and the fourth-tier measures within the *Focused* branch.

The two values that comprise the second tier of the value *Focused* are *Innovative* and *Leverage*, each having local weights of 0.65 and 0.35, respectively. The global weights are 0.163 and 0.088, respectively. While assigning a moderate level of importance to a potential initiative's ability to leverage existing resources (i.e., technology, contracts, expertise, and POC venues), the FPB felt *Innovative* deserved more importance in weighting. They base this decision on the first sentence in the opening paragraph of AFI 10-1901 (which is an excerpt from the Air Force *Global Engagement* document, page 9): "The key to ensuring today's Air Force core competencies will meet the challenge of tomorrow is Innovation" (Department of the Air Force, 1997:2) (Jurk, 2002).

3.5.4.1 Weights for the Values Under *Innovative*

The FPB personnel place slightly more importance on *Appropriate Selection* than *Strategy of Determination*; therefore, the local weights are 0.55 and 0.45, respectively. The global weights are 0.089 and 0.073, respectively. While the FPB personnel indicated that both values were important in helping to select an initiative, "they acknowledged that they would rather have a promising potential initiative executed with a poor proof of concept strategy than a poor potential initiative executed with a great proof of concept strategy" (Jurk, 2002:176).

3.5.4.2 Weights for the Measures Under *Appropriate Selection*

The FPB personnel place the most importance on the measure *Urgency* followed closely by *Level of Request.* They feel that the submitting unit's status is far less important than the worth of the initiative, but still a valid evaluation criteria. Therefore,

the local weights of *Urgency*, *Level of Request*, and *Unit Status* are 0.55, 0.4 and 0.05, respectively. The global weights are 0.049, 0.035, and 0.004, respectively. The FPB personnel reason that the urgency of a force protection need should receive more weight than who is submitting the request. The global weights for each measure comprising the *Focused* branch are shown in Table 11.

3.5.4.3 Weights for the Measures Under *Strategy of Determination*

The FPB personnel place the most importance on the measure *Estimated Time to Complete an Initiative* followed by *Sensibility*, *Performance Risk*, *Schedule Risk*, and *Cost Risk*. The local weights for each measure are 0.35, 0.3, 0.15, 0.1, and 0.1, respectively. Note that the global weights are displayed in Table 11. *Estimated Time to Complete an Initiative* is considered the most important by FPB personnel because of their directive to "Rapidly identify and prove the worth of innovative ideas…" (Department of the Air Force, 1997:2). The measure *Sensibility* received the second most local weight because the FPB personnel acknowledged that more reasonable potential initiatives had higher chances of being successful (Jurk, 2002). Regarding the three risk measures of *cost*, *schedule*, and *performance*, the FPB personnel felt they were all very close in importance. Of these three, they place the most importance on *Performance Risk*, which echoes their desire to avoid complications throughout the entire life of an initiative (Jurk, 2002). The FPB personnel place the least amount of importance on *cost risk* and *schedule risk*. This is because they feel that *cost risk* and *schedule risk are* easier to mitigate than performance risk. For comparative purposes, the global weights for each measure comprising the *Focused* branch are shown in Table 11.

3.5.4.4 Weights for the Values Under *Leverage*

The FPB personnel placed decreasing amounts of importance on *Existing Technology*, *Existing Expertise*, *Existing Contracts,* and *Existing POC Venues*. The local weights are 0.4, 0.3, 0.2, and 0.1, respectively. Note that the global weights are displayed in Table 11. FPB personnel indicated leveraging *Existing POC Venues* was the least important value because "they felt a POC venue could either be created or simply was not a concern for a good initiative properly executed by the AO" (Jurk, 2002: 159). The value *Existing Contracts* was deemed twice as important as *Existing POC Venues* because of the time and effort required to establish a contract. The value *Existing Expertise* was deemed three times as important as *Existing POC Venues. F*PB personnel acknowledge that leveraging expertise external to the battlelab would allow them to execute more initiatives than normal. Finally, the FPB personnel placed four times the importance on leveraging *Existing Technology* as they did on *Existing POC Venues*. The reason was that they wanted to encourage the innovative use of commercial and government off-the-shelf (COTS and GOTS) technology to address force protection issues (Jurk, 2002).

3.5.4.5 Weights for the Measures Under *Leverage*

With the exception of *Existing Technology,* each third-tier value under *Leverage* has only one measure associated with it. Therefore, each measure receives a local weight of 1.0. The value *Existing Technology* has two measure s assigned to it: *Leverage Multiple Technologies* and *Degree of Leverage.* FPB personnel felt that the degree to which technology was leveraged was slightly more important than an initiative

leveraging multiple types of technologies. Therefore, the local weights for *Degree of Technology* and *Leverage Multiple Technologies* are 0.55 and 0.45, respectively. The global weight for each measure is shown in Table 11.

Table 11. Global Weights for *Focused* Branch Measures

***Focused* Branch Measures**	**Global Weight**
Level of Request	0.036
Urgency	0.049
Unit Status	0.004
Estimated Time to Complete an Initiative	0.026
Cost Risk	0.007
Schedule Risk	0.007
Performance Risk	0.011
Sensibility	0.021
Degree of Leveraging Existing Technology	0.019
Leverage Multiple Technologies	0.016
Degree of Leveraging Existing Contracts	0.018
Degree of Leveraging Existing Expertise	0.026
Degree of Leveraging Existing POC Venues	0.009

3.5.5 Weights for the Impact Branch Values

The value *Impact* was assigned 35 percent of the total weight of importance distributed between the four first-tier values. The global weight for *Impact* is also 0.35. This branch, as with all four branches, was weighted by the FPB division chiefs and approved by the commander. The global weight for *Impact* is 0.35.

The four values that comprise the second tier of the value *Impact* are *Prove Concepts*, *Advance AF Core Competencies*, *Drive Revisions*, and *Improve Warfighting*, each having local weights of 0.2, 0.35, 0.15, and 0.3, respectively. The global weights are 0.07, 0.123, 0.053, and 0.105, respectively. The FPB division chiefs "assigned the highest weight of importance to *Advance AF Core Competencies* because their mission statement in AFI 10-1901 highlights the vital role Air Force core competencies play in furthering the entire nation's military capabilities" (Jurk, 2002: 162). The FPB personnel assigned the second highest weight of importance to the value *Improve Warfighting*. FPB personnel felt that impacting the warfighter was vital to the Air Force and their mission; thus, it received a high weight also. The FPB personnel also acknowledge that being able to drive revisions to Air Force organization, doctrine, training, requirements, and acquisitions was also a valuable effect to have, but they felt that proving concepts as directed in their doctrine (Department of the Air Force, 1997) is slightly more important. Therefore, they assigned *Prove Concepts* a slightly higher weight of importance than *Drive Revisions*.

3.5.5.1 Weights for the Values Under *Prove Concepts*

The FPB personnel provided the following local weights for *Rapid Fielding*, *Long Lasting*, *Wide Impact,* and *Logistics Tail*. The local weights are 0.3, 0.25, 0.25, and 0.2 respectively. The global weights are 0.021, 0.018, 0.018, and 0.014 respectively. The most emphasis was placed on the value *Rapid Fielding* because the FPB personnel feel that complying with the rapid fielding directive of their governing doctrine is of utmost importance. *Wide Impact* and *Long Lasting* are weighted slightly below *Rapid* Fielding. FPB personnel are "compelled by their mission statement to positively affect as many Air Force personnel as possible with successful force protection initiatives" (Jurk, 2002: 163). The FPB personnel also wish for the impact to be as permanent as possible and thus assigned the value *Long Lasting* equal importance to *Wide Impact.* Finally, FPB personnel felt that the size of an initiatives logistical tail was important for the initiatives long-term sustainment and efficient use of resources; however, they deem it to be less critical than affecting Air Force personnel globally in an expedient manner.

3.5.5.2 Weights for Values Under *Advance AF Core Competencies*

To achieve visual symmetry at the fourth tier and allow easy understanding of the hierarchical structure, the only value under *Advance AF Core Competencies* is *Advance Multiple Core Competencies*. Therefore, it receives 100 percent of the emphasis, its local weight is 1.0, and its global weight is 0.123.

3.5.5.3 Weights for the Values Under *Drive Revisions*

The FPB personnel ranked the importance of *Doctrinal Revisions, Training Revisions, Requirements Revisions, Organizational Revisions,* and *Acquisition Revisions*

with the following local weight values: 0.3, 0.2, 0.2, 0.15, and 0.15, respectively. The global weights are 0.016, 0.011, 0.011, 0.008, and 0.008, respectively. The FPB personnel place a high emphasis on positively affecting revisions to Air Force doctrine because it reflects the largest scale change possible in terms of revision to Air Force policy (Jurk, 2002). The FPB personnel "acknowledge training as a key enabler of the Air Force to accomplish its mission" (Jurk, 2002: 165) and therefore weight it slightly less than *Doctrinal Revisions* and equal with *Requirements Revisions* which also represent a key component of the Air Force's process of acquiring and fielding new technology. The FPB personnel placed the remaining weight in *Organizational Revisions* and *Acquisition Revisions*, each of which was deemed to have less importance on the FPB fundamental objective with *Organizational Revisio*ns being slightly more important than *Acquisition Revisions*.

3.5.5.4 Weights for the Values Under *Impact Warfighting*

The FPB personnel felt that an impact on furthering the support of homeland defense efforts was more important than the potential for involving other government agencies or sister services. Therefore, the local weights for the two values under *Impact Warfighting* (*Homeland Defense* and *External Participation*) are 0.6 and 0.4, respectively. The global weights for the values are 0.063 and 0.042, respectively.

3.5.5.5 Weights for the Measures Under the *Impact* Branch

Each third-tier value within the *Impact* branch has only one measure associated with it. Therefore, each measure receives a local weight of 1.0. The global weight for each measure is shown in Table 12.

Table 12. Global Weights for *Impact* Branch Measures

***Impact* Branch Measures**	**Global Weight**
Level of Impact	0.018
Estimated Time to Field	0.021
Longevity	0.018
Logistics Tail	0.014
Number of AF Core Competencies Advanced	0.123
Significant Organizational Revisions	0.008
Significant Doctrinal Revisions	0.016
Significant Training Revisions	0.011
Significant Requirements Revisions	0.011
Significant Acquisitions Revisions	0.008
Extra-Agency Involvement	0.042
Impact on Homeland Defense	0.063

3.6 Alternative Generation

The next step of the value-focused thinking process, alternative generation, is not applicable to this research effort. Most FPB potential initiatives are not generated internally, but rather, they are collected from the general population. For this research effort and the data generated herein, the initiatives used were those provided by FPB personnel. These initiatives were selected from a pool of ongoing, already completed, and potential initiatives.

3.7 Alternative Scoring and Deterministic Results

To properly score an initiative, first data must be collected for each measure in the VFT hierarchy. Once the data has been collected, the alternative can receive an x-axis value for each of the measure's SDVF. This step can be accomplished by a single subject matter expert or by a group of subject matter experts. Deterministic analysis involves converting the measure scores into a value score for each initiative; it allows the decision maker to see a comparative ranking of the various alternatives on an absolute scale. The x-axis value (obtained as described above) is mapped to a y-axis value (via the SDVF) and provides the value for each individual measure. Finally, the sum product of each measure's value with each measure's global weight, as determined during the hierarchy weighting, provides the total value for the alternative.

3.8 Optimizing the Initiative Selection Process

The final step of the future value analysis process involves optimizing the solution. In the case of choosing FPB initiatives, this involves generating a portfolio of initiatives that maximizes the value provided to the FPB while staying within the constraints of their operation. The technique used in this selection optimization problem was constraint-based linear programming using Microsoft Excel Solver.

The objective function used to select the optimal portfolio can be seen in equation 1. It involves maximizing the total value of initiatives, as determined by the initiative's value model scores, that are selected to be supported by the FPB.

Objective Function

$$\text{Maximize} \quad Z = \sum_{n}\sum_{m} X_{nm} \cdot V_n \qquad \textit{Equation 1}$$

X = decision variable that selects person *m* to work on initiative *n*
V= value model score of initiative *n*
n = number of initiatives
m = number of action officers

X_{nm} is 0 or 1. 0 = initiative *n* is not selected to be worked on by person *m*
1 = initiative *n* is selected to be worked on by person *m*

The objective function was created to maximize the value model scores of the potential initiatives. *X* is the decision variable that determines if an initiative is selected or not. *V* is the value model score of an initiative.

3.8.1 Developing the Constraint Set

The constraints used in this linear programming problem were determined by discussions with FPB personnel pertaining to the resources that hamper their ability to do work when those resources are depleted. The three primary resources that were initially conceived of by FPB personnel were money, time and personnel.

3.8.1.1 Budget Constraint

The FPB receives an approximate annual budget of $4.7 million, with approximately $3.7 million being allocated to initiatives. This money is then allocated by the commander into the various initiative efforts. Thus, the sum of the individual costs of all the selected initiatives cannot exceed $3.7 million. This represents the only budgetary constraint and can be expressed mathematically as shown in equation 2. *C* represents the cost of an initiative to the FPB. *B* represents the FPB budget for initiatives.

$$\sum_{m}\sum_{n} X_{nm} \cdot C_n \leq B \qquad \textit{Equation 2}$$

C = cost of initiative *n* in dollars
B = Total FPB Budget in dollars

3.8.1.2 Time Constraint

It was determined through interviews with FPB personnel, that only one AO would work a single initiative at a time. Although occasional support is provided from personnel other than the assigned AO, it was determined that this support took an insignificant portion of time. Thus, a constraint of the model must limit the number of personnel working on an initiative to one. This is represented by equation 3.

$$\sum_{m} X_{nm} \leq 1 \quad \text{for all } n \qquad \textit{Equation 3}$$

3.8.1.3 Manpower Constraint

The final resource that controls the amount of initiatives that the FPB can select is available manpower. This constraint is two fold. The first half involves the availability of each AO to work. The second half involves any specialty areas required to work on an initiative.

Availability of each AO constraint

The FPB is mandated to operate rapidly and with minimal manpower (Department of the Air Force, 1997), thus the amount of time available for AOs to work on initiatives is finite. To capture the time required by each initiative, the *Efficiency* measure under the *Lean* branch was used in the constraint set. The *Efficiency* measure gauges whether an initiative requires an AO full-time or part-time. A full-time initiative

is described by FPB personnel as one that requires a majority of that AO's time per day. After further discussion with FPB personnel, it was determined that the best approximation of this was that a full-time initiative requires 3/4 of an AO's time per day. Conversely, a part-time initiative requires only a small fraction of an AO's time. FPB personnel decided that part-time initiatives require 1/4 of an AO's time per day. The FPB currently has 38 personnel that perform tasks as action officers. This number of 38 includes the 25 permanently assigned personnel as well as additional contractors that have been hired to help support initiatives as AOs. Thus the sum of the selected part-time initiatives multiplied by 1/4, plus the sum of the selected full-time initiatives multiplied by 3/4 cannot exceed 38. This relationship is shown in equation 4. For purposes of this study, it was decided that each AO would only be allowed to work a regular shift. That is, there would be no consideration of overtime; thus, each AO could only work up to 1 unit of initiatives.

$$\sum_{n} X_{nm} \cdot T_n \leq 1 \quad \text{for all } m \qquad \textbf{\textit{Equation 4}}$$

T represents the fraction of an AO's time required to work on an initiative (taken from the *efficiency* measure).

Specialty Areas Constraint

The FPB receives initiative proposals dealing with hundreds of unique topics and subject areas. Because of this, the FPB structure incorporates personnel of varying ranks, Air Force Specialty Codes (AFSCs), and experiences. Certain initiatives that are

submitted to the FPB can only be worked on by personnel who are proficient in specific areas of knowledge. Thus, not all AOs can work on every initiative. Discussions with FPB personnel helped define 23 unique specialties that may be required for certain initiatives. These specialties are listed in Table 13. The 38 AOs were then assigned one or more of these specialties based on their career field and job experience. Each individual and their specialties are shown in Table 14. Note that every action officer is automatically assigned the specialty code 16, general action officer, therefore it is not listed in the table. This constraint is represented by equation 5 and supported by equations 6 and 7.

$$X_{nm} - Y_{nm} < 1 \qquad \textbf{\textit{Equation 5}}$$

where

$$Y_{nm} = \sum_{D} S_{mD} \cdot N_{nD} \quad \text{for all } n \text{ and } m \qquad \textbf{\textit{Equation 6}}$$

Y = The variable that describes whether person *m* has the required specialty expertise to work on initiative *n*
Y = 0 if person *m* cannot work on initiative *n*
Y = 1 if person *m* can work on initiative *n*
S = Vector of variables representing the specialties of person *m*
N = Vector of variables representing the specialties that can perform work on initiative *n*
D = number of specialties
S and *N* are binary variables for all *D*

$$\text{If } Y_{nm} \geq 1 \text{ then } Y_{nm} = 1 \quad \text{for all } n \text{ and } m \qquad \textbf{\textit{Equation 7}}$$

The variable Y (equation 6) represents a variable that denotes whether an FPB personnel has the required specialty to work as the AO for an initiative. The variable *S* identifies all the specialties that each FPB personnel possess. The variable *N* represents the specialties required to work as AO on each initiative.

Table 13. Specialty Listings

Specialty	Code
Security Forces (SF) / Law Enforcement	1
SF / Security	2
CE/civil- blast and frag	3
CE/ Explosive Ordnance Disposal(EOD)	4
CE/ Readiness	5
Intel/ general	6
Intel/ application	7
Tactical Air Control Party (TACP)	8
General Scientist 62/63 AFSC	9
Finance	10
Communications	11
BioEnvironmental Engineering	12
Nurse	13
Medical Technician	14
Medical Administration	15
Doctor	17
General Action Officer	16
Modeling and Simulation	18
Flying/Pilot	19
Microbiologist	20
Medical Scientist	21
Command and Control	22
Operations Analyst	23

Table 14. Personnel and Specialties

Personnel	Specialty Codes assigned
Deputy	17
LtCol English	19
CMSgt Jones	1
TSgt Simmons	10
LtCol Greene	1,2
Capt Gooding	1,2
SMSgt Mikell	1
Mr Flaherty	1,2,4,5,22,23
Mr Shakell	1,2,4,5,22,23
Mr Lowe	1,2,4,5,22,23
LtCol Rau	9
Capt Skiba	4
Capt Moriarty	3
SMSgt Kunich	1
MSgt Hernandez	6
MSgt Hite	8
MSgt Madeline	5
Maj Mcfadden	7
Capt Stuller	11
Mr Cronin	18
Mr Scrivener	18
Mr Fryer	18
Mr Smyth	18
Capt Meana	1,2
SMSgt Jordan	2
MSGt Davis	2
Mr Coleman	2,18
Mr Buckley	2,18
Mr Doyle	2,18
Mr Comeaux	2,18
Maj Barnes	20
Maj Bowles	12
Maj Watson	13
Capt Nail	13
Capt Kelly	13
Mr White	21
TSgt Aviles	14
Maj Lawson	1,2

3.8.2 Implementing the Integer Programming problem in Solver

The full linear programming formulation involves the maximization of the value of initiatives selected by the FPB. This maximization of value must be accomplished without violating the constraint conditions of budget, time, and manpower. It includes the objective function and constraints described above and includes the binary variable constraint (equation 8).

X_{nm} is binary for all n and m ***Equation 8***

After the constraint set was developed and defined by the constraint mathematical equations below, the equations and objective equation were entered into a Microsoft Excel spreadsheet. Using the Solver software utility, the project selection optimization was conducted.

Chapter 4. Results and Analysis

This chapter contains the results of the deterministic and sensitivity analysis performed on the 21 initiatives scored using the value focused thinking model. Additionally, the portfolio of initiatives selected during the linear optimization are also examined and discussed.

4.1 Deterministic Analysis of the VFT Model

The deterministic analysis examines the results of the VFT model and provides insight into the relative value provided to the FPB for each initiative scored. Specifically, the deterministic analysis highlights the measures and values that contribute the most value to the FPB fundamental objective, and hence are the most influential. The 21 initiatives scored are listed in Table 15 with their relative rankings**.** The initiative rankings were determined with respect to their value model scores, with *vehicle profiling software* having the highest value score.

Table 15. Ranking of Initiatives based on VFT scores

Initiative	Ranking
Vehicle Profiling Software	1
Biological Swab Sampler (BSS)	2
Electrostatic Decontamination System (EDS)	3
AMC Tent City Visualization	4
REDCAR	5
Visualization for Personnel Readiness	6
Ultra Wide Band Communications	7
CBR counter terrorism training kits (CBRCT)	8
Smart Shirt	9
Body Armor Cooling System (BACS)	10
Worm Drive Solar Barrier System	11
Visitor Entry Screening Process (VESP)	12

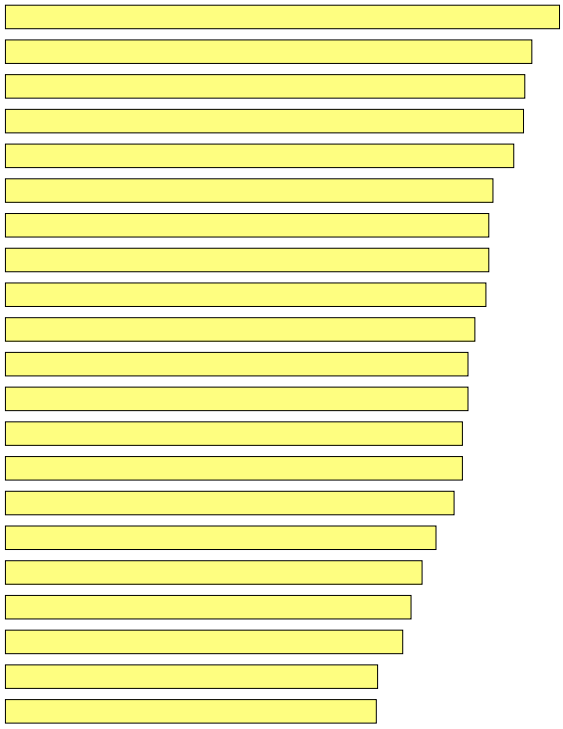
Initiative	Ranking
Personal Role Radio (PRR)	13
Through the Wall Visibility	14
360 Video Support	15
Blast Effects Estimation Model (BEEM)	16
Standoff Explosive Detection (SEPD)	17
Blast Panel DFP	18
K-9 Boss	19
Transparent Armor Development (TAD)	20
Laser Threat Database and Detector Project (LDFAS)	21

Each of these initiatives was scored using the VFT hierarchy, and the value score is shown in Figure 18. The ranking of initiatives is based on an absolute scale; therefore a higher score is indicative of greater value added to the FPB fundamental objective. More effort will be taken to explain the reason for ranking the top initiative versus the others.

In order to provide insight into the score of each initiative, we can look at ranking graphs that are broken into the four branches of the hierarchy. Figure 19 shows the value added to each initiative with respect to the four branches of the hierarchy. This figure shows that the highest ranked initiative, *Vehicle Profiling Software*, scored well in all four branches. Conversely, the lowest scoring initiative, *Laser Threat Database and Detector Project,* scored poorly in both the *Focused* and *Impact* branches. This figure also confirms the relative importance placed on the four branches by the FPB commander's weighting; *Impact* is generally the largest piece of an initiatives score, followed by *Focused* and *Unique*, and lastly by the lesser weighted *Lean* branch.

Ranking for FPB Initiative Selection Goal

Alternative	Utility
Vehicle Profiling Software	0.79097
BSS	0.75208
EDS	0.74268
AMC Tent City Visualization	0.73996
REDCAR	0.72748
Visualization for Personnel Readiness	0.69706
Ultra Wide Band Comm	0.69127
CBRCT	0.69090
Smart Shirt	0.68695
BACS	0.67183
Worm Drive Solar Barrier System	0.66169
VESP	0.66074
PRR	0.65365
Through the Wall Visibility	0.65260
360 Video Support	0.64142
BEEM	0.61678
SEPD	0.59717
Blast Panel DFP	0.57945
K-9 Boss	0.56834
TAD	0.53216
LDFAS	0.53088

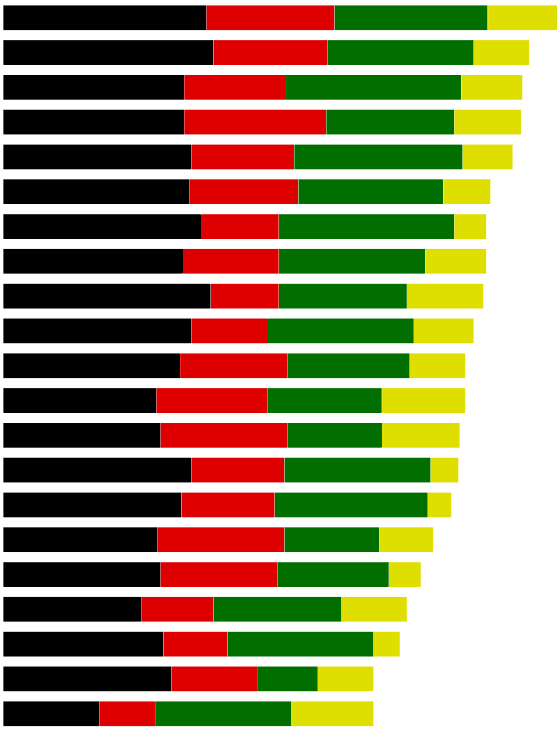


Preference Set = NEW PREF. SET

Figure 18. Initiative Value Scores

Ranking for FPB Initiative Selection Goal

Alternative	Utility
Vehicle Profiling Software	0.79097
BSS	0.75208
EDS	0.74268
AMC Tent City Visualization	0.73996
REDCAR	0.72748
Visualization for Personnel Readiness	0.69706
Ultra Wide Band Comm	0.69127
CBRCT	0.69090
Smart Shirt	0.68695
BACS	0.67183
Worm Drive Solar Barrier System	0.66169
VESP	0.66074
PRR	0.65365
Through the Wall Visibility	0.65260
360 Video Support	0.64142
BEEM	0.61678
SEPD	0.59717
Blast Panel DFP	0.57945
K-9 Boss	0.56834
TAD	0.53216
LDFAS	0.53088



Impact Focused Unique
Lean

Preference Set = NEW PREF. SET

Figure 19. Initiative Value Scores by Branch

The appendix contains each initiative's score broken into the relative value added by each of the 35 measures in the VFT hierarchy. This provides a macroscopic view of the value added from an initiative under a particular measure and can be used to both provide insight into why an initiative scored well/poorly, or provide an area to focus on improving to increase an initiative's value score.

In Chapter 3, the global weights for all 35 measures in the hierarchy were tabulated. Figure 20 shows the measures of all four branches ranked according to their global weight. *# of Core Competencies* is the largest contributor to an initiative's value score followed closely by *Degree of FP Correlation*. These two measures contribute 24.25% of the total possible score for an initiative. Constituting slightly more than 6% to an initiative's score, *Impact on Homeland Defense,* is the third highest weighted measure. *Degree of Similarity* and *Urgency* are the fourth and fifth largest contributor's, respectively, at just less than 5% global weighting each. These top five globally weighted measures are responsible for 40.47% of an initiative's total score, and thus the most important measures to be scored accurately. Deviation and incorrect estimates in the SDVFs for these measures during the scoring process can result in skewed value rankings and ultimately non-optimal decisions.

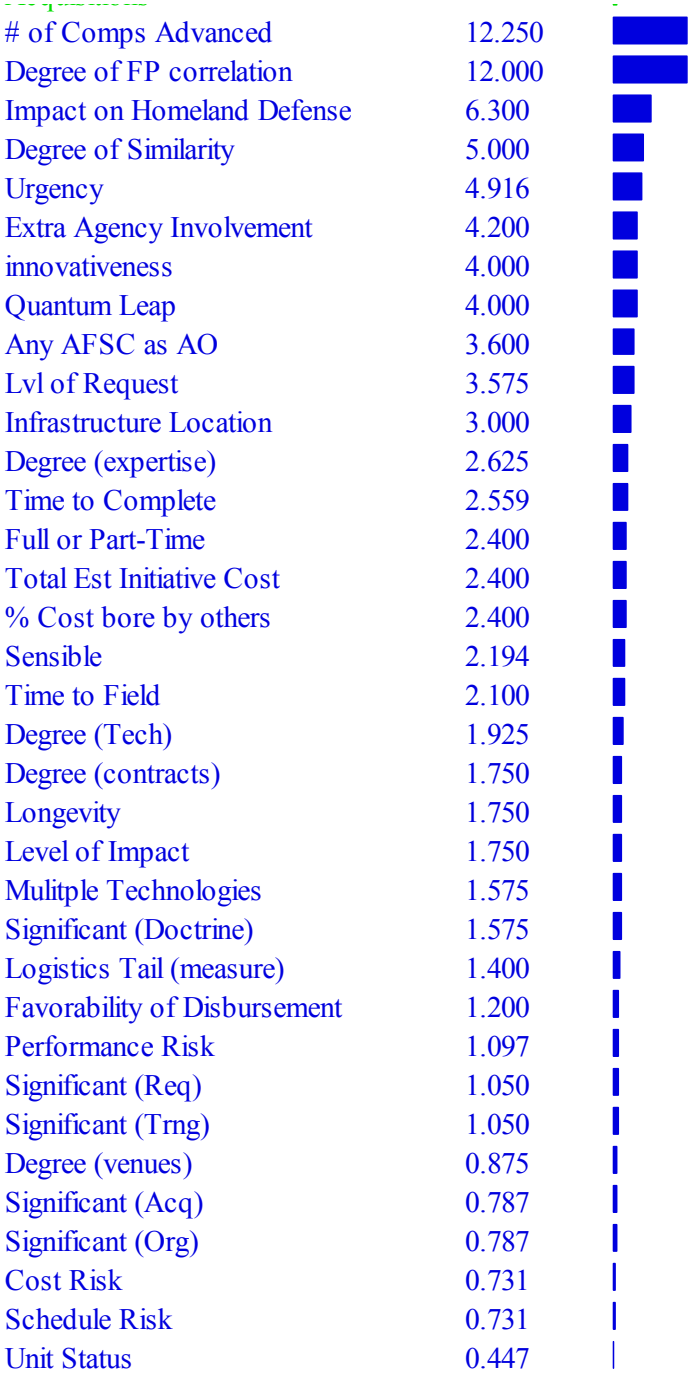


Figure 20. Global Measure Weights

4.2 Sensitivity Analysis of the VFT Model

The sensitivity analysis of the VFT model will be performed on the top tier of the hierarchy; specifically, analysis will be performed on the first-tier values of *Lean, Unique, Focused,* and *Impact.* Sensitivity analysis on this level of the hierarchy will allow the model to be tested for robustness and responsiveness to dynamic changes in the hierarchy weighting.

4.2.1 Sensitivity Analysis on the Lean Branch

Figure 21 shows the sensitivity graph for the top six alternatives with respect to the *Lean* first-tier value. Figure 22 shows the sensitivity graph for the bottom six alternatives with respect to the *Lean* first-tier value. As indicated by the graph, the top initiative, *Vehicle Profiling Software*, remains the top initiative until the weighting for *Lean* increases to 0.58. Above a weighting of 0.58, *Visitor Entry Screening Process,* becomes the highest ranked alternative. If the weighting continues above 0.74, *Personal Role Radio* and *Smart Shirt*, become the next best alternatives, behind *Visitor Entry Screening Process* and above *Vehicle Profiling Software.* If the *Lean* weight is increased above 0.80, then *Laser Threat Database and Detector Project* surpasses all initiatives except *Visitor Entry Screening Process.* However, in order for a new initiative to surpass the top four existing initiatives, the global weighting for the *Lean* branch of the hierarchy would have to shift to more than 0.35 from its current weight of 0.15. This would likely only be caused by a dramatic shift in values or mission requirements in the FPB. Similarly, the bottom five initiatives will not change unless the weighting for *Lean* is

increased to 0.27. This would also require a strong emphasis shift in the FPB initiative selection philosophy.

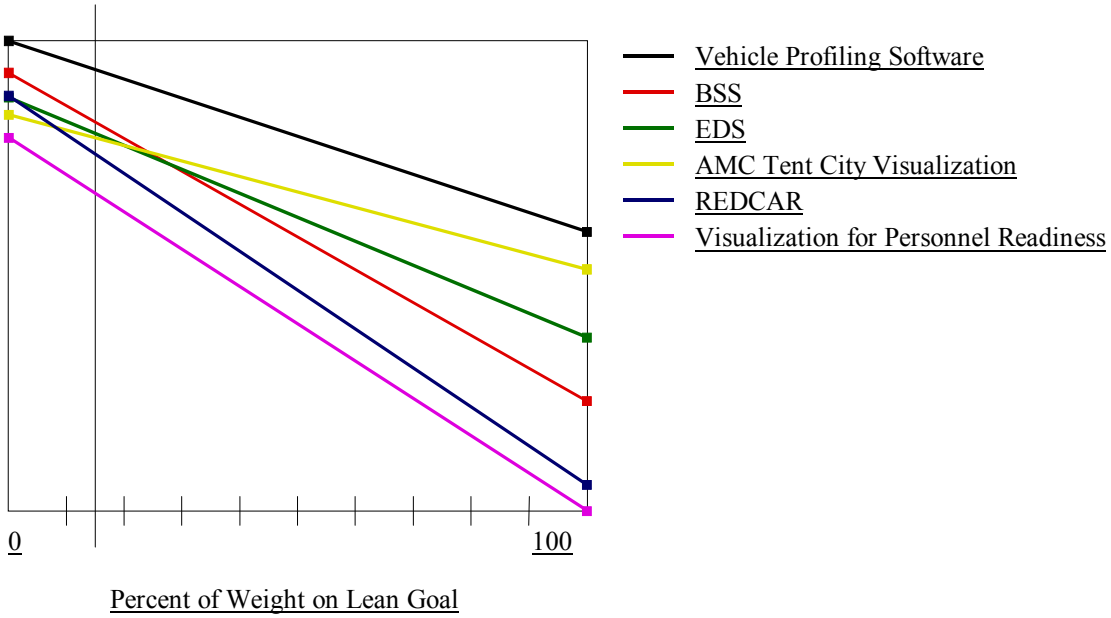


Figure 21. Lean Branch Sensitivity Graph- Top 6

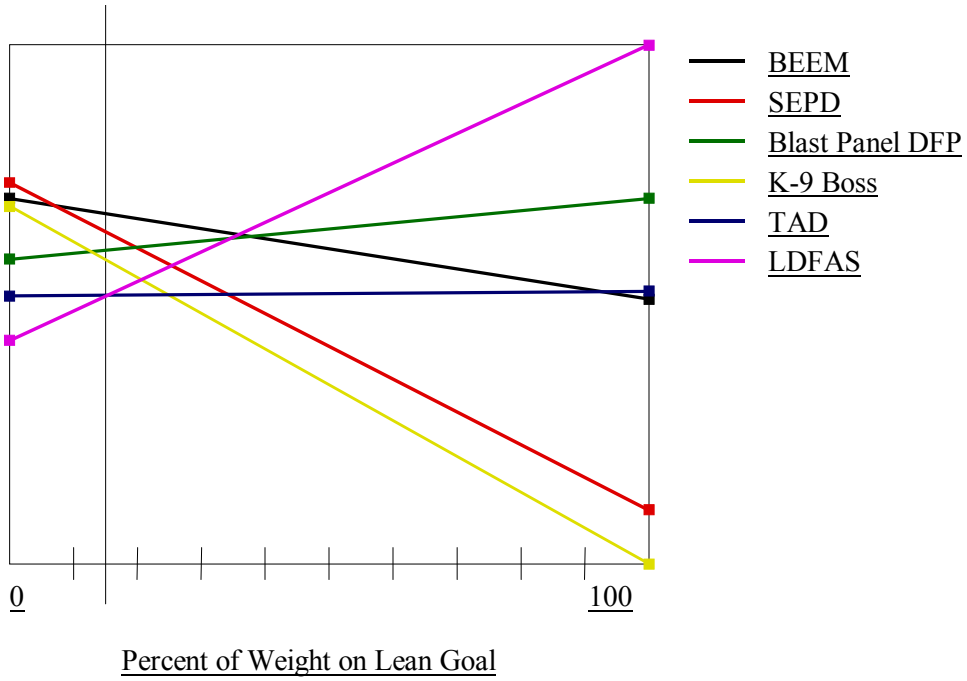


Figure 22. Lean Branch Sensitivity Graph- Bottom 6

4.2.2 Sensitivity Analysis on the Unique Branch

Figure 23 shows the sensitivity graph for the top six alternatives with respect to the *Unique* first-tier value. Figure 24 shows the sensitivity graph for the bottom six alternatives with respect to the *Unique* first-tier value. As indicated by the graph, the top initiative, *Vehicle Profiling Software*, remains the top initiative until the weighting for *Unique* increases to 0.44. Above a weighting of 0.44, *EDS* becomes the highest ranked alternative. If the weighting continues above 0.56, *Ultra WideBand Comm* and *REDCAR* become the next best alternatives, behind *EDS.* However, for any of the top five initiatives to fall to the sixth highest requires a positive shift of 0.10 or a negative shift of 0.15 in the weighting for *Unique,* from its base value of 0.25. This would likely only be caused by a dramatic shift in values or mission requirements in the FPB.

Similarly, the bottom five initiatives will not change unless the weighting for *Lean* is increased to 0.35 or decreased below 0.10. This would also require a strong emphasis shift in the FPB initiative selection philosophy.

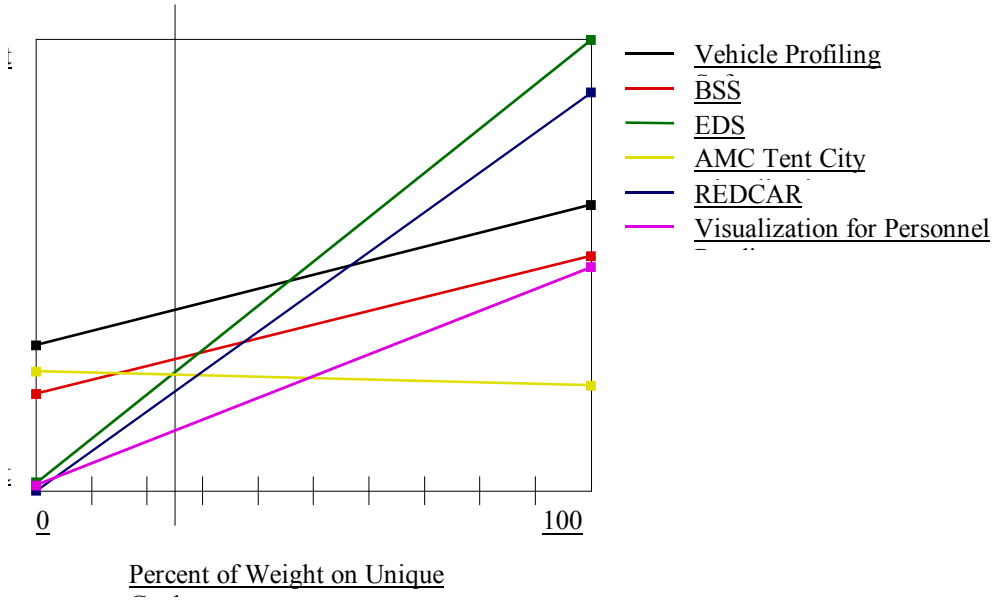


Figure 23. Unique Branch Sensitivity Graph- Top 6

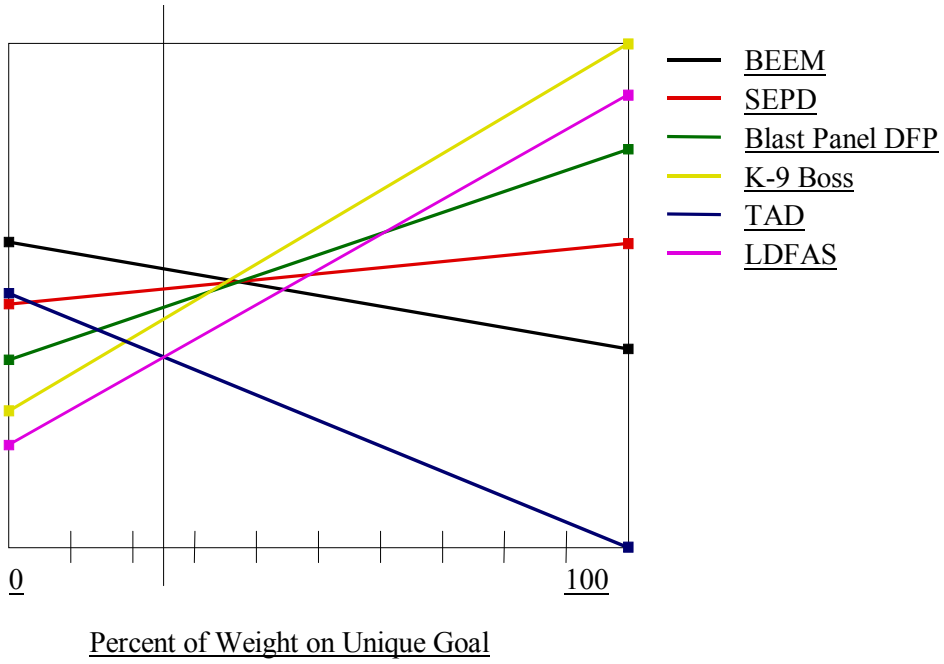


Figure 24. Unique Branch Sensitivity Graph- Bottom 6

4.2.3 Sensitivity Analysis on the Focused Branch

Figure 25 shows the sensitivity graph for the top six alternatives with respect to the *Focused* first-tier value. Figure 25 shows the sensitivity graph for the bottom six alternatives with respect to the *Focused* first-tier value. As indicated by the graph, the top initiative, *Vehicle Profiling Software*, remains the top initiative until the weighting for *Unique* increases to 0.54. Above a weighting of 0.54, *AMC Tent City Visualization* becomes the highest ranked alternative and it will remain the top choice even if the *Focused* weighting increases to 1.0. If the weighting continues above 0.54, the next three best alternatives are (3) *BSS*, (4) EDS, and (5) *REDCAR*. These top five initiatives will remain in the same order until the global weight for the *Focused* value increases

above 0.52. This would once again only be caused by a dramatic shift in values or mission requirements in the FPB. If the *Focused* value decreases below a weight of 0.15 then *Smart Shirt* and *Ultra Wide Band Comm* become better initiatives than *AMC Tent Visualization.* Further reduction of the *Focused* weighting, below 0.07 global, will entail *BACS* and *CBRCT* surpassing the score of *AMC Tent Visualization* as well. However, the previously mentioned top three initiatives remain in the top three even with a *Focused* global weight reduction of 0.0. Similarly, the bottom five initiatives will not change unless the weighting for *Lean* is increased to 0.42 or decreased below 0.15.

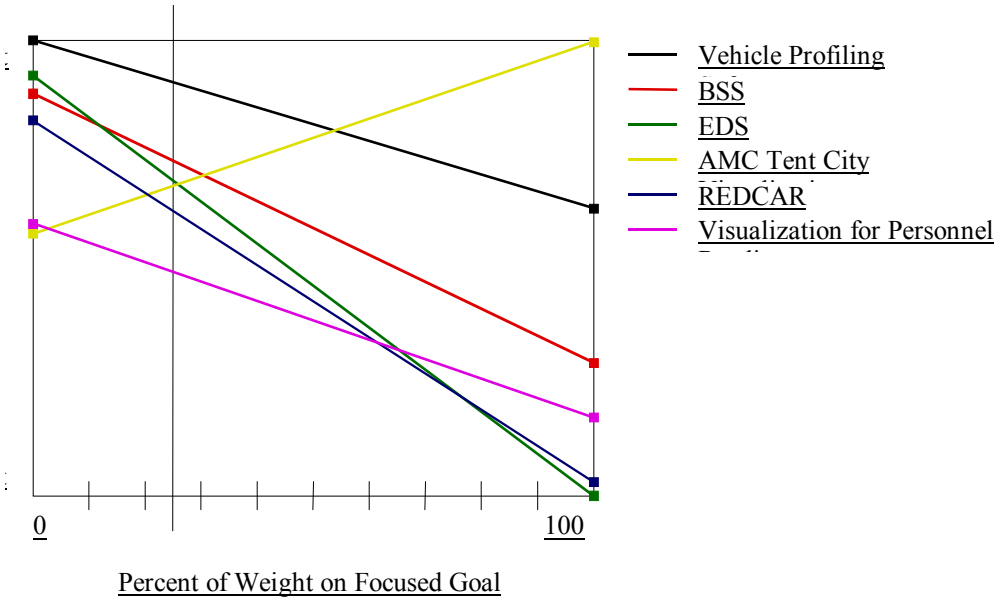


Figure 25. Focused Branch Sensitivity Graph- Top 6

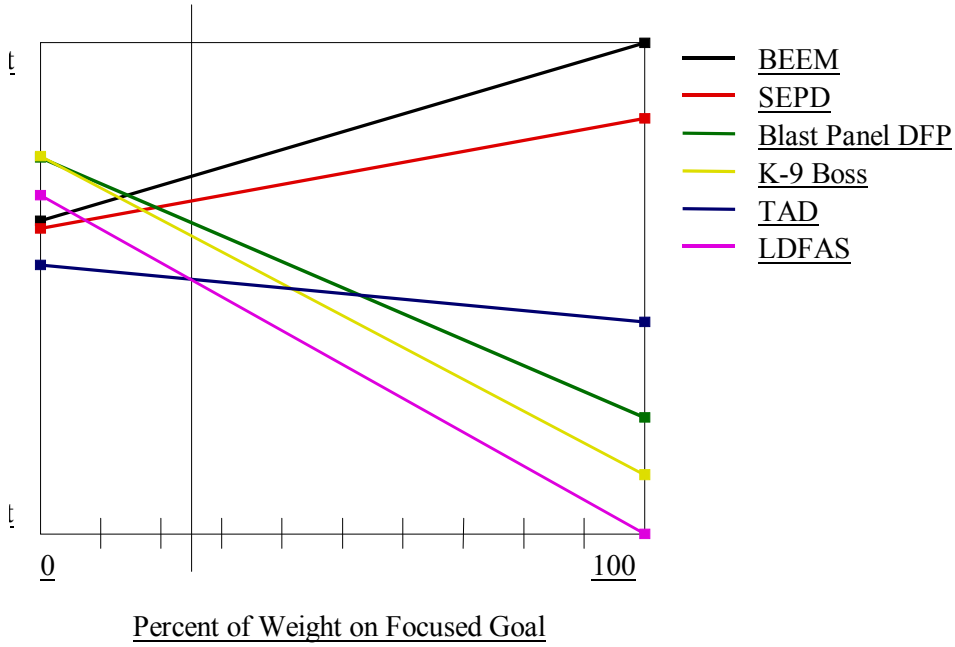


Figure 26. Focused Branch Sensitivity Graph- Bottom 6

4.2.4 Sensitivity Analysis on the Impact Branch

Figure 27 shows the sensitivity graph for the top six alternatives with respect to the *Impact* first-tier value. Figure 28 shows the sensitivity graph for the bottom six alternatives with respect to the *Impact* first-tier value. As indicated by the graph, the top initiative, *Vehicle Profiling Software*, remains the top initiative until the weighting for *Unique* increases to 0.74. Above a weighting of 0.74, *BSS* becomes the highest ranked alternative and it remains the top choice even if the *Impact* weighting increases to 1.0. The top five initiatives remain in the top five unless the global weighting for *Impact* increases above 0.56. Above 0.56 *Smart Shirt* surpasses *REDCAR, AMC Tent*

Visualization, and *EDS* as the number three initiative. Finally, if the global weighting for *Impact* is increased above 0.62, then *Ultra Wide Band Comm* becomes the fourth bets initiative followed by *REDCAR*. The global weight for *Impact* can decrease to 0.0 and the top five initiatives will remain unchanged with the exception of *BSS* falling from number three to number five. Similarly, the bottom five initiatives will not change unless the weighting for *Lean* is increased to 0.73 or decreased below 0.05. This would once again only be caused by a dramatic shift in values or mission requirements in the FPB. This data shows that the *Impact* branch is the least sensitive of the four branches to a change in weighting.

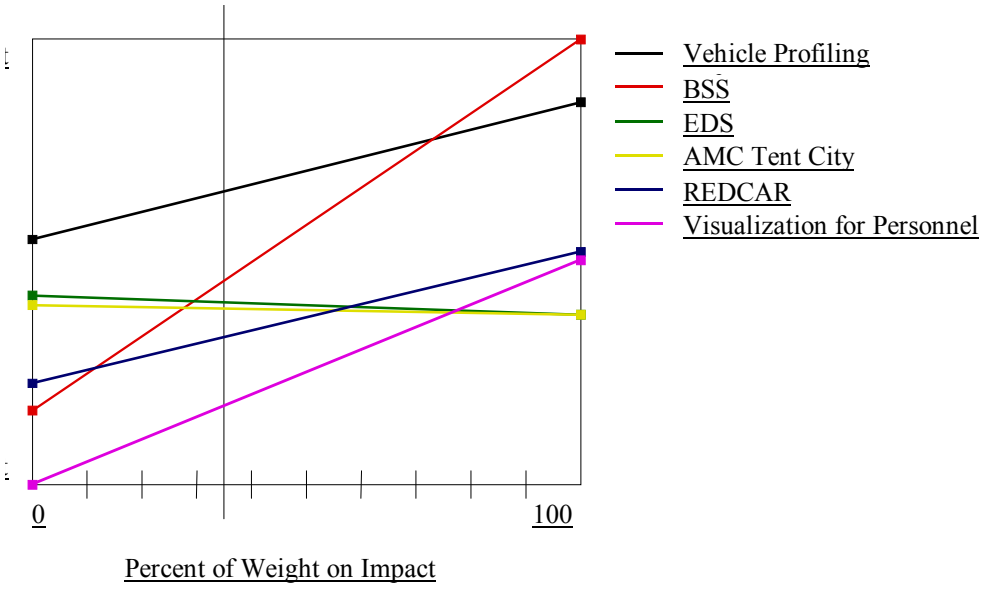


Figure 27. Impact Branch Sensitivity Graph-Top 6

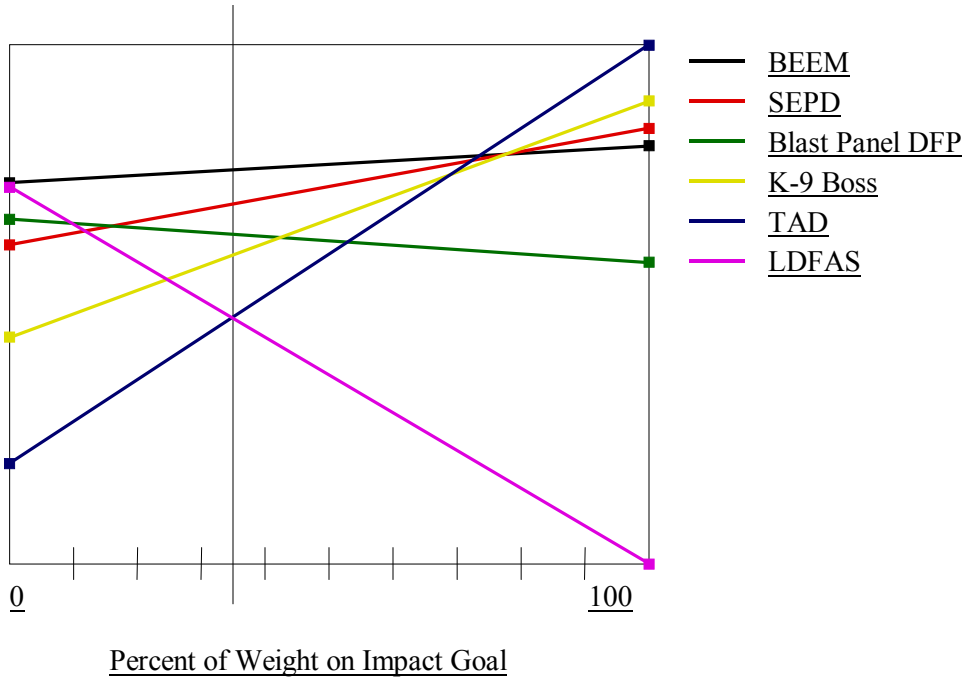


Figure 28. Impact Branch Sensitivity Graph- Bottom 6

4.3 Results of Linear Optimization

This section will detail the results of the selection of a portfolio of initiatives using linear optimization. The methodology detailed in Chapter 3 was followed in laying out the constraint and objective criteria.

Twenty-one initiatives were used in the portfolio selection. The constraint data for each of these initiatives was provided by subject matter experts at the FPB, and the value (objective) data was taken from the VFT scoring of each initiative. Because twenty-one initiatives is a small subset of the total number of initiatives that the FPB evaluates, the optimization model only provides a "proof of concept" for future FPB

optimization techniques. Therefore, the results of the optimization are not fully realized. Normally, the FPB would be reviewing 100 initiatives or more, rather than 21. To attempt to compensate for this, an optimization was performed using 20% of the FPB budget ($740,000), which is approximately the same percentage of initiatives (compared to normal), 21 out of 100, that were reviewed.

Table 16 shows the results of the linear optimization with the expected annual budget of $3.7M; the highlighted initiatives are those that were selected by the optimization model. With this amount of money and manpower, the FPB is able to select 20 initiatives (all initiatives except for *REDCAR*). The total cost is $3.247M, below the $3.7M threshold, and the total value of the initiatives selected is 13.105. *REDCAR* is not selected in this portfolio because it has a prohibitive cost. Even though it scored well in the value model (0.714, the fifth highest value score), its estimated cost of $850,000 makes it a less advantageous selection than several less expensive initiatives that provide a greater combined value. Once again, because 21 is a small subset of initiatives, the manpower constraint is not a critical factor in the portfolio selection.

Table 16. Results of Optimization, $3.7M

Initiatives	Value Score	Cost
Ultra Wide Band Communications	0.681	$ 150,000.00
Through the Wall Visibility	0.642	$ 300,000.00
360 Video Support	0.649	$ 175,000.00
Visualization for Personnel Readiness	0.687	$ 750,000.00
Standoff Explosive Detection	0.592	$ 250,000.00
Vehicle Profiling Software	0.796	$ 175,000.00
Worm Drive Solar Barrier System	0.651	$ 80,000.00
Blast Panel DFP	0.574	$ 200,000.00
Laser Threat Database and Detector Project	0.526	$ 20,000.00
Visitor Entry Screening Process	0.666	$ 115,000.00
AMC Tent City Visualization	0.746	$ 50,000.00

Initiatives	Value Score	Cost
PRR	0.661	$ 50,000.00
K-9 Boss	0.563	$ 287,000.00
Body Armor Cooling System	0.665	$ 100,000.00
Transparent Armor Development	0.539	$ 100,000.00
smart shirt	0.687	$ 80,000.00
Electrostatic Decontamination System	0.731	$ 150,000.00
REDCAR	0.714	$ 850,000.00
Blast Effects Estimation Model	0.625	$ 50,000.00
CBR counter terrorism training kits	0.684	$ 75,000.00
Biological Swab Sampler	0.74	$ 90,000.00
	All initiatives	$ 4,097,000.00
Constraint Totals:	13.105	$ 3,247,000.00
		<=
	FPB max	$ 3,700,000.00

Considering the small subset, several more optimizations were performed while lowering the FPB budget constraint to $2.5M and $2M. Table 17 shows the results of the linear optimization with the expected annual budget of $2.5M. With this amount of money and manpower, the FPB is able to select 19 initiatives-- all initiatives except for *REDCAR* and *Visualization for Personnel Readiness*. The total cost is $2.497M, and the total value of the initiatives selected is 12.418. As in the previous optimization run, *REDCAR* is not selected. In addition to *REDCAR, Visualization for Personnel Readiness* is also not selected for a similar reason. Even though it scored fairly well in the value model (0.687), its estimated cost of $750,000 is cost prohibitive. Therefore, it does not provide enough value for its estimated cost. The manpower constraint is also not a critical factor in this portfolio selection.

Table 17. Results of Optimization, $2.5M

Initiatives	Value Score	Cost
Ultra Wide Band Communications	0.681	$150,000.00
Through the Wall Visibility	0.642	$300,000.00
360 Video Support	0.649	$175,000.00
Visualization for Personnel Readiness	0.687	$750,000.00
Standoff Explosive Detection	0.592	$250,000.00
Vehicle Profiling Software	0.796	$175,000.00
Worm Drive Solar Barrier System	0.651	$80,000.00
Blast Panel DFP	0.574	$200,000.00
Laser Threat Database and Detector Project	0.526	$20,000.00
Visitor Entry Screening Process	0.666	$115,000.00
AMC Tent City Visualization	0.746	$50,000.00
PRR	0.661	$50,000.00
K-9 Boss	0.563	$287,000.00
Body Armor Cooling System	0.665	$100,000.00
Transparent Armor Development	0.539	$100,000.00
smart shirt	0.687	$80,000.00
Electrostatic Decontamination System	0.731	$150,000.00
REDCAR	0.714	$850,000.00
Blast Effects Estimation Model	0.625	$50,000.00
CBR counter terrorism training kits	0.684	$75,000.00
Biological Swab Sampler	0.74	$90,000.00
	All initiatives	$4,097,000.00
Constraint Totals:	12.418	$2,497,000.00
		<=
	FPB max	$2,500,000.00

Table 18. Optimization Selection with $2M

Initiatives	Value Score	Cost
Ultra Wide Band Communications	0.681	$150,000.00
Through the Wall Visibility	0.642	$300,000.00
360 Video Support	0.649	$175,000.00
Visualization for Personnel Readiness	0.687	$750,000.00
Standoff Explosive Detection	0.592	$250,000.00
Vehicle Profiling Software	0.796	$175,000.00
Worm Drive Solar Barrier System	0.651	$80,000.00
Blast Panel DFP	0.574	$200,000.00
Laser Threat Database and Detector Project	0.526	$20,000.00
Visitor Entry Screening Process	0.666	$115,000.00
AMC Tent City Visualization	0.746	$50,000.00
PRR	0.661	$50,000.00
K-9 Boss	0.563	$287,000.00
Body Armor Cooling System	0.665	$100,000.00
Transparent Armor Development	0.539	$100,000.00
smart shirt	0.687	$80,000.00
Electrostatic Decontamination System	0.731	$150,000.00
REDCAR	0.714	$850,000.00
Blast Effects Estimation Model	0.625	$50,000.00
CBR counter terrorism training kits	0.684	$75,000.00
Biological Swab Sampler	0.74	$90,000.00
	All initiatives	$4,097,000.00
Constraint Totals:	11.184	$1,947,000.00
		<=
	FPB max	$2,000,000.00

Table 18 shows the results of the linear optimization with the expected annual budget of $2M. With this amount of money and manpower, the FPB is able to select 17 initiatives-- all initiatives except for *REDCAR, Visualization for Personnel Readiness, Stand-off Explosive Detection (SEPD),* and *Through the Wall Visibility*. The total cost is $1.947M, and the total value of the initiatives selected is 11.184. In addition to *REDCAR*

and *Visualization for Personnel Readiness, Through the Wall Visibility* and *SEPD* were not selected. *Through the Wall Visibility* and *SEPD* scored 0.642 and 0.592, respectively in the value model, with estimated costs of $300,000 and $250,000. With the reduced budget allowance, both of these initiatives failed to provide enough added value for the incurred cost. Once again, because 21 is a small subset of initiatives, the manpower constraint is not a critical factor in the portfolio selection.

Table 19. Optimization Selection with $740K

Initiatives	Value Score	Cost
Ultra Wide Band Communications	0.681	$ 150,000.00
Through the Wall Visibility	0.642	$ 300,000.00
360 Video Support	0.649	$ 175,000.00
Visualization for Personnel Readiness	0.687	$ 750,000.00
Standoff Explosive Detection	0.592	$ 250,000.00
Vehicle Profiling Software	0.796	$ 175,000.00
Worm Drive Solar Barrier System	0.651	$ 80,000.00
	0.574	$ 200,000.00
Laser Threat Database and Detector Project	0.526	$ 20,000.00
Visitor Entry Screening Process	0.666	$ 115,000.00
AMC Tent City Visualization	0.746	$ 50,000.00
PRR	0.661	$ 50,000.00
K-9 Boss	0.563	$ 287,000.00
Body Armor Cooling System	0.665	$ 100,000.00
	0.539	$ 100,000.00
smart shirt	0.687	$ 80,000.00
Electrostatic Decontamination System	0.731	$ 150,000.00
REDCAR	0.714	$ 850,000.00
Blast Effects Estimation Model	0.625	$ 50,000.00
CBR counter terrorism training kits	0.684	$ 75,000.00
Biological Swab Sampler	0.74	$ 90,000.00
	All initiatives	$ 4,097,000.00
Constraint Totals:	6.651	$ 710,000.00
		<=
	FPB max	$ 740,000.00

Finally, an optimization was performed using a budget of 20% of the original budget, or $740,000. This is a similar percentage (21 out of 100) to the number of initiatives that were reviewed in this study (21) compared to the number of initiatives that would be reviewed in a normal FPB initiative selection session (100). Table 19 shows the results of the linear optimization with the expected annual budget of $740K. With this amount of money and manpower, the FPB is able to select 8 initiatives, highlighted in the table. The total cost is $710K, and the total value of the initiatives selected is 6.651. With the reduced budget allowance, those initiatives with the lowest value/cost ratio were not selected. Once again, because 21 is a small subset of initiatives, the manpower constraint is not a critical factor in the portfolio selection.

Table 20. Knapsack Results $740K

Initiatives	Value Score	Cost	Cum Cost
Vehicle Profiling Software	0.796	$ 175,000.00	$ 175,000.00
AMC Tent City Visualization	0.746	$ 50,000.00	$ 225,000.00
Biological Swab Sampler	0.740	$ 90,000.00	$ 315,000.00
Electrostatic Decontamination System	0.731	$ 150,000.00	$ 465,000.00
REDCAR	0.714	$ 850,000.00	
Visualization for Personnel Readiness	0.687	$ 750,000.00	
smart shirt	0.687	$ 80,000.00	$ 545,000.00
CBR counter terrorism training kits	0.684	$ 75,000.00	$ 620,000.00
Ultra Wide Band Communications	0.681	$ 150,000.00	
Visitor Entry Screening Process	0.666	$ 115,000.00	$ 735,000.00
Body Armor Cooling System	0.665	$ 100,000.00	
PRR	0.661	$ 50,000.00	
Worm Drive Solar Barrier System	0.651	$ 80,000.00	
360 Video Support	0.649	$ 175,000.00	
Through the Wall Visibility	0.642	$ 300,000.00	
Blast Effects Estimation Model	0.625	$ 50,000.00	
Standoff Explosive Detection	0.592	$ 250,000.00	
Blast Panel DFP	0.574	$ 200,000.00	
K-9 Boss	0.563	$ 287,000.00	
Transparent Armor Development	0.539	$ 100,000.00	
Laser Threat Database and Detector Project	0.526	$ 20,000.00	
	All initiatives		
Constraint Totals:	5.05	$ -	
		<=	
	FPB max	$ 740,000.00	

To provide a comparison of the optimized result to a deterministic result (i.e., knapsack solution) and show it's potential benefit, a knapsack solution was performed with the same reduced budget of $740K. The Results are shown in Table 20. Using this approach the FPB is able to select 7 initiatives to pursue, 3 less than the optimized solution. *REDCAR*, *Visualization for Personnel Readiness*, and *Ultra Wide Band Communications* are not selected because they would drive the cumulative project total over the allotted budget. The total value for the knapsack solution is also more than 30% lower than the optimized solution with the same constraints.

4.4 Summary

Chapter 4 reviewed the results of using the value model with 21 FPB initiatives to determine the value each contributed to the FPB fundamental objective. The deterministic value scores, shown in Figure 18, indicate that the *Vehicle Profiling Software* initiative contributes the greatest value to the FPB. These deterministic results provide a useful tool to the FPB commander to help choose initiatives to fund and pursue. Furthermore, a summary of all the FPB proposed initiatives, not just these 21, would provide a solid relative ranking upon which to make initiative selections.

The sensitivity analysis performed using the global weights of the first-tier values (*Lean, Unique, Focused,* and *Impact*) indicated where the results were sensitive to changes in the global weights. For each first-tier value examined through sensitivity analysis, the top five initiatives remained fairly insensitive to change in the first-tier weights. This lends credibility to any decision made to support and fund these initiatives. Similarly, the bottom five initiatives remained fairly insensitive to change in first-tier

weights as well, which provides justification for excluding them from funding and support.

Finally, the results of the portfolio selection of initiatives using linear optimization were detailed. The results provide a sound "proof of concept" of the usefulness of such techniques in the initiative selection process. The optimization portrayed the fact that choosing initiatives purely based on their value model score is not the optimal strategy for selection. The analysis also revealed the major constraints placed upon the FPB, manpower and budget. Although a full optimization of all proposed FPB initiatives, rather than the subset of 21 analyzed herein, would have provided a detailed portfolio of initiatives to choose, this research provides the framework for such an analysis to eventually take place.

Chapter 5: Findings and Conclusions

Chapter 5 provides an overall view of the findings in this thesis effort. This chapter draws conclusions regarding the applicability of the future value analysis process in force protection initiative selection applications. In doing so, it addresses the revised VFT model created to measure the value of such initiatives and describes the usefulness of constraint-based optimization in the selection process. Finally, Chapter 5 suggests possible follow-on research areas.

5.1 Future Value Analysis and the FPB

As previously stated, Future Value Analysis is a "combination of three methods to assess future opportunities: (1) a strategic assessment of future opportunities and challenges, (2) a multiple-objective decision analysis using value-focused thinking, and (3) a portfolio analysis using optimization" (Parnell, 2002). Last year, the FPB accomplished the first two steps of this process through the analysis of their initiative selection process and the creation of a VFT hierarchy to rank those initiatives. That research provided the groundwork for the FVA concept to be implemented into the FPB operational routine for initiative selection.

This thesis details the transition from strictly using a multi-objective decision making process into using the FVA process. This first required the validation and reworking of the FPB's existing VFT model to encompass changing requirements brought about by the recent focus on force protection across the United States. The most important change to the VFT model was the addition of the new measure *Impact on Homeland Defense*, which accounts for 6.3% of an initiative's total score and is the third

most heavily weighted measure in the new hierarchy. This measure is a direct reflection of the new emphasis on force protection issues.

Once the hierarchy was validated and updated, the third step of the FVA process was accomplished: providing an optimal portfolio of initiatives using linear optimization. Through consultation with the FPB, the following set of constraints were developed: manpower, budget, and time. First, the FPB is limited to an annual budget of $3.7M for initiatives. The FPB is also limited to 25 military personnel, with a small contingency of contractor support. Finally, the FPB has a limited number of personnel with the specialized experience that some initiatives require to manage. By maximizing the value provided, as taken from the model value scores, while adhering to these three constraints, an optimal portfolio of initiatives was selected.

The final major accomplishment of this thesis effort was the implementation of the research into a usable form for FPB personnel. Using commercial software, the VFT model was input with documentation to provide a tool for future use at the FPB. The "proof of concept" work done using linear optimization was also implemented into readily available software.

5.2 Model Strengths and Weaknesses

The primary strength of the value model is its platinum standard hierarchy (Parnell, 2002). This entails that the model is fundamentally based on battlelab doctrine and written guidance, with additional input and expert opinion from senior level members of the organization (e.g., division chiefs). The model is also robust and fairly insensitive to changes in the top-tier weights. The sensitivity analysis adequately details how

changes in first-tier value weighting will have limited affect on initiatives value scores and minimal affect on the top five initiatives. One of the model's weaknesses from a year ago has now been turned into a strength. Last year's model contained two measures that accounted for almost 50% of the overall model weighting. The highest weighting for a measure this year is 12.25%, and only 3 of the 35 measures have a weighting of over 5 percent. This further reduces the sensitivity of the model to any one measure dominating the solution. Another strength of the model is that it is in its second revision. It now more truly reflects the values and preferences of the FPB commander in today's environment. Additionally, the model's strength is enhanced by its generality.

Because it is based primarily on battlelab guidance, as opposed to force protection guidance, it can be a useful primer for future implementation at the other Air Force battlelabs. Although the other battlelabs have slightly different missions, the model would provide a defensible, objective, and repeatable process for evaluating innovative ideas at all AF battlelabs. Finally, the model's strength is enhanced by the inclusion of an optimization component. By using linear optimization, the portfolio of initiatives that provides the best value, within the constraining demands placed upon the FPB, can be selected as opposed to choosing initiatives based solely on their value model score. This optimization allows for a better allocation of resources, while accomplishing as much or even more work.

The prominent weakness of the value model is the lack of uncertainty. Because the FPB deals with new technology and applications, there is inherent uncertainty present. Many of the measures are estimates based on a vague working knowledge of the initiatives. Currently, this is not accounted for in the model, and best-guess estimates are

used to score each initiative. The model also does not consider the uncertainty associated with the construction of the SDVFs. To combat this, a working group was responsible for determining the values of the SDVF categories. Another weakness of the model is the need for time to score by working group. The measures and SDVFs were designed to be scored by the same group personnel for all initiatives. This will require continuity to be kept up and time dedicated to the process. But group scoring, although time intense, will ensure the best possible, unbiased, data is available to the decision maker.

5.3 Conclusion

This research has provided the framework in support of using the Future Value Analysis process in the force protection arena. Through the validation and subsequent optimization of a value model, the FPB now has an implementable tool to help them select the best portfolio of initiatives. This tool will provide a repeatable, defensible, and objective process upon which to make decisions.

5.4 Recommendations for Future Work

This research has created a framework for future research opportunities dealing with FVA and the FPB. The first recommendation for future work is to incorporate the inherent uncertainty in initiative selection into the model. This can be done using probabilistic techniques in both the SDVFs and the optimization solution. The incorporation of uncertainty will provide a more detailed aggregate picture to the decision maker and will also remove some of the error associated with scoring initiatives using estimation procedures.

Another recommendation for future work is the creation of a data collection tool and library. Such a tool will allow for historical records to be stored on past initiatives that may provide insight into ongoing and future initiatives. It will also allow for a more seamless integration of the value model and optimization components. Along with the data library, a collection tool could be created to more easily gather data on proposed initiatives from field agencies. This could both reduce additional processing requirements and allow for an automated screening criteria tool for new initiatives.

Another possible area for future research deals with the advancement of the optimization component. Possible areas for improvement are in the addition of new constraints (i.e. adding the option of contracting out certain specialties), or allowing for simple implementation of forcing decision variables into a static state. This would allow for the decision maker to force certain initiatives into a position of definitely "select/do not select" regardless if they are included in the optimal solution. Finally, a possible area of future work would be in the integration of the optimization techniques, the value model, and the data collection tool into a simplistic combined interface. This would provide a convenient all in one package that would speed up and provide additional clarity into the decision making process.

Appendix A: Working Group Meeting Notes

FPB AFIT Meeting 2: 18 Sept 2002

Location: FPB, Lackland AFB, TX

Present from FPB: LtCol Green, LtCol Ozment, Capt Moriarty, Capt Stuller, CMSgt Jones

Present from AFIT: Capt Robert Eskridge, Capt Stephen Chambal

Meeting Purpose:

1. Provide an overview briefing of the work done by AFIT last year. Detail the Value Focused Thinking (VFT) model process that was used and describe the specific model that was created for the FPB.

2. Obtain feedback from the FPB personnel on the areas of the model they feel needs improvement as well as obtain information detailing critical areas of initiative selection that were left out of last year's work.

3. Detail our plan of attack for the next four months and work out preliminary dates for future visits.

Meeting Highlights:

1. An overview briefing was given by Capt Chambal. It briefly described the VFT process. It further detailed the model hierarchy used last year, describing each of the value areas. Finally, the briefing detailed the plan for this year's research effort. This entailed revisiting last year's model to validate it and correct or clarify any areas of concern with the model. It also described the next two phases of this year's work: collecting data on the constraints placed upon the FPB(manpower, funding, time…), and using linear programming to provide an optimal portfolio of initiatives based on those constraints.

2. The meeting then progressed into the first phase of the project, readdressing last year's value hierarchy. The working group worked through each branch of the existing hierarchy and was asked to comment on anything they felt was missing or was inappropriate.

3. The first branch of the hierarchy deals with the principle of Leanness. The following issues were brought up.

    a. The question was raised as to whether the number of months to complete an initiative was included.

    b. The issue was brought up that General Shamus is focused on Money, Manpower, and Equipment. It was decided that it was important that these factors be included in the model. Specifically, the logistics tail of an initiative needed to be included. Possible issues here are O&M costs, training costs, and difficulty of implementing due to high logistical concerns.

    c. The measure "percentage bore by others" was a concern. It was felt that a monetary value was needed instead of a percentage.

4. The second branch that was discussed was the Uniqueness branch. The following issues were brought up.

    a. It was felt that the model was missing a "leap of faith"/"quantum leap" factor. This factor would deal with an initiative providing a level of value because of its possible potential to better the Air Force even though it far from any other current initiative in scope.

    b. The question was also raised as to the validity of the non-duplication value. Specifically, it was felt that duplication could be valid if the FPB was pursuing a short term fix to a problem, while another agency pursued a long term fix.

5. The third branch that was discussed was the Focused branch. The following issues were brought up.

    a. It was felt that more detail was needed in the level of request value. This could include the addition of which service branch submitted the request as well as adding in different agencies (i.e. FBI, CIA…)

    b. The issue of multiple requesting agencies was brought up because it is not currently covered in the existing model.

    c. A key issue which was brought up is the idea of sponsorship. This is a broad area and the group was unclear on whether it was fully covered in the VFT model. Specifically, the transition of an initiative to a sponsor was brought up as well as having a sponsor for sustainment. Also, there was a concern that sponsorship being available was not included.

d. It was also felt that initiatives leveraging multiple technologies was not accounted for.

6. The fourth branch that was discussed was the Impact branch. The following issues were brought up.

a. In the "drive revisions" values, the question was raised as to whether the wording should be changed from "Air Force" to "DOD". It was agreed that this was not in line with the FPB principles and mission.

b. The issue was raised as to whether or not the model took into account the initiatives impact on Homeland Defense. This was tied with a concern that the "Joint involvement" value did not give credit for involvement with other agencies (FBI, CIA…).

c. The issue of giving credit for the type of mission(peacekeeping, war-time, anti-terrorism…) an initiative supported was raised.

d. The issue of whether an initiative should be scored on whether it impacted CONUS or overseas locations was raised.

7. A plan of future meetings was also created. It was decided that these issues would be researched and addressed by the next meeting (9 Oct). At that time, AFIT will also have created a new hierarchy based on the concerns and comments of this meeting. Any new measures will have value functions created by the FPB personnel at the Oct 9 meeting. AFIT will also provide an initiative worksheet at the Oct 9 meeting to be filled out for any initiatives that the FPB would like to have reviewed in this year's research project. The final goal of the Oct 9 meeting is to create the constraint variables of the FPB. This will likely include manpower issues, budget issues, and time issues.

8. During the time between the Oct 9 meeting and an as yet unscheduled Nov meeting, the FPB will submit the worksheets they have generated on the initiatives they wish to include in the research. These will be entered into the VFT software by AFIT and a brief walkthrough and demonstration of the scoring process will be provided at the November meeting.

FPB AFIT Meeting 3: 8-9 Oct 2002

Location: FPB, Lackland AFB, TX

Present from FPB: LtCol Green, LtCol Ozment, LtCol Rau, Maj Barnes, Capt Moriarty, CMSgt Jones

Present from AFIT: Capt Robert Eskridge, Capt Stephen Chambal

Meeting Purpose:

4. Provide an overview briefing of the revised hierarchy created after FPB meeting 2.

5. Create single dimension value functions (SDVF) for the new measures. Weight the new VFT hierarchy at the division chief level.

6. Develop constraint set to be used in proof of concept optimization of FPB initiatives selection.

Meeting Highlights:

9. A summary of changes to the hierarchy was provided to the FPB in advance of the meeting. This detailed the changes made to the hierarchy including the addition of new measures. The group first proceeded to create SDVFs for each of the new measures. This involved both the creation of the x-axis for each SDVF and the creation of the value curve. A group concensus was reached on each of the 5 new measure's SDVF.

10. The meeting then progressed into the weighting of the VFT hierarchy. AFIT personnel facilitated the process, and the members of the FPB provided the weights for each of the branches. The weighting was accomplished locally on each tier of each of the four branches.

11. A second meeting was held on 9 Oct between Capt Moriarty and Capt Eskridge. The purpose of this meeting was to generate the constraint set to be used in the optimization portion of the analysis. After a detailed discussion, the following three primary constraints were created: FPB Budget, Specialty required, and Total Manpower required. The FPB budget was estimated to be $4.7M(with ~ $3.7M spent on initiatives). The specialties were broken down into 23 distinct areas, and each of the personnel assigned to FPB was assigned one or more of these specialties.

12. A plan of future meetings was also created. For the next meeting, scheduled tentatively for early December, AFIT will have created the VFT hierarchy in

Logical decisions. AFIT will also provide an initiative worksheet to be completed before the next meeting by FPB personnel on any initiatives they would like scored. AFIT will present the software package and demonstrate some of its capabilities at the December meeting.

Appendix B: VFT Hierarchy and VFT Results

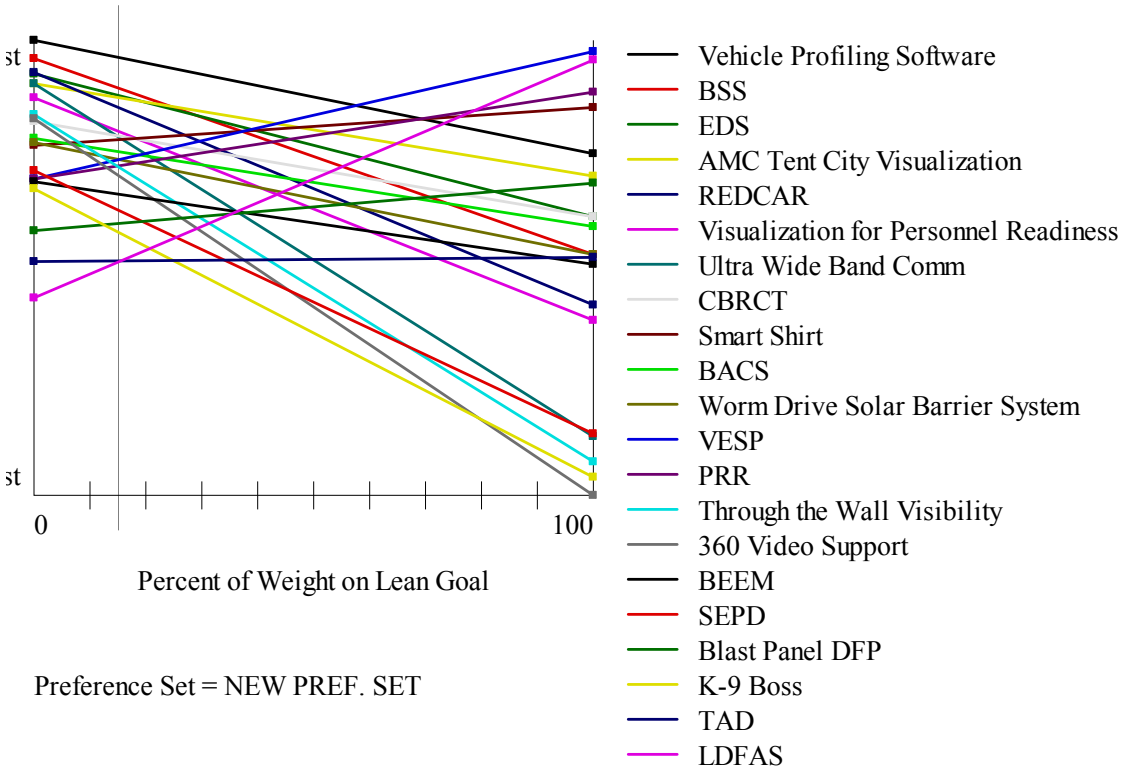


Figure 29. Sensitivity Results- Lean Value

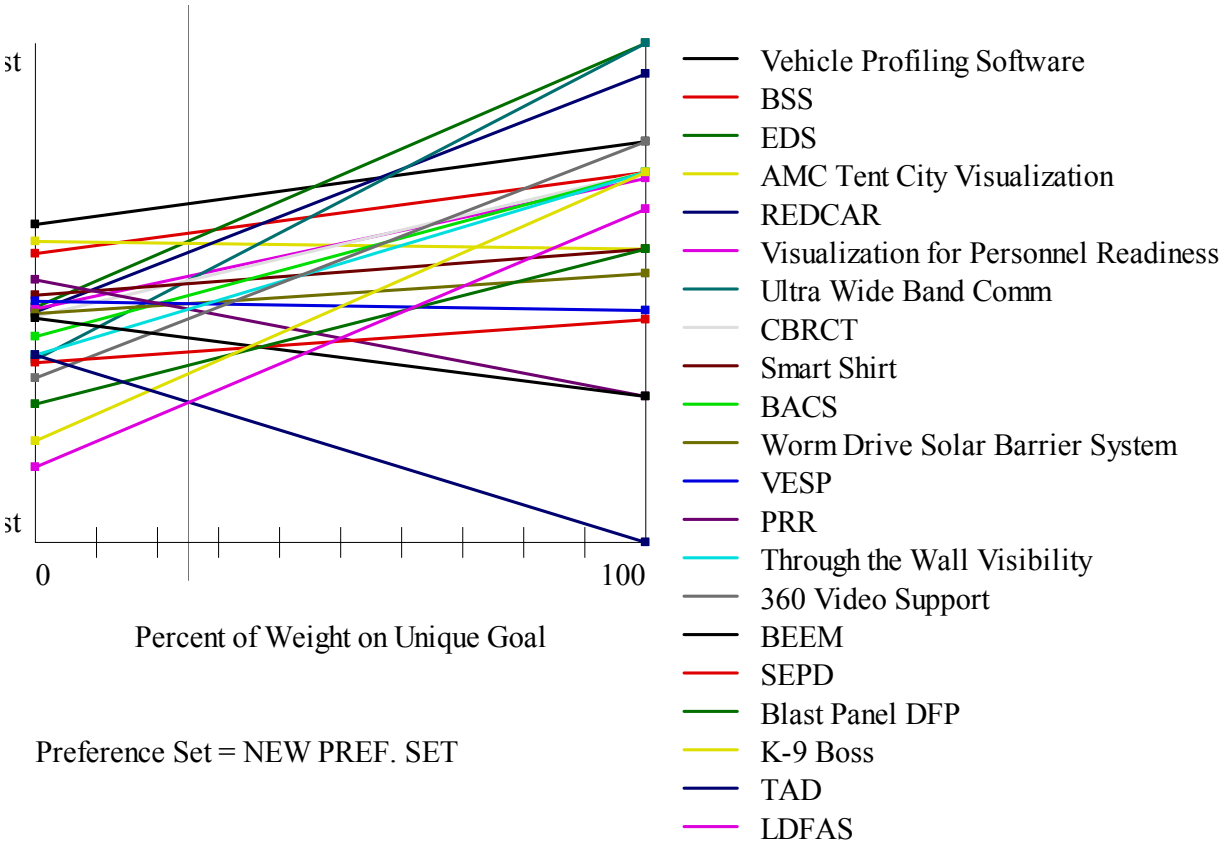


Figure 30. Sensitivity Results Unique Value

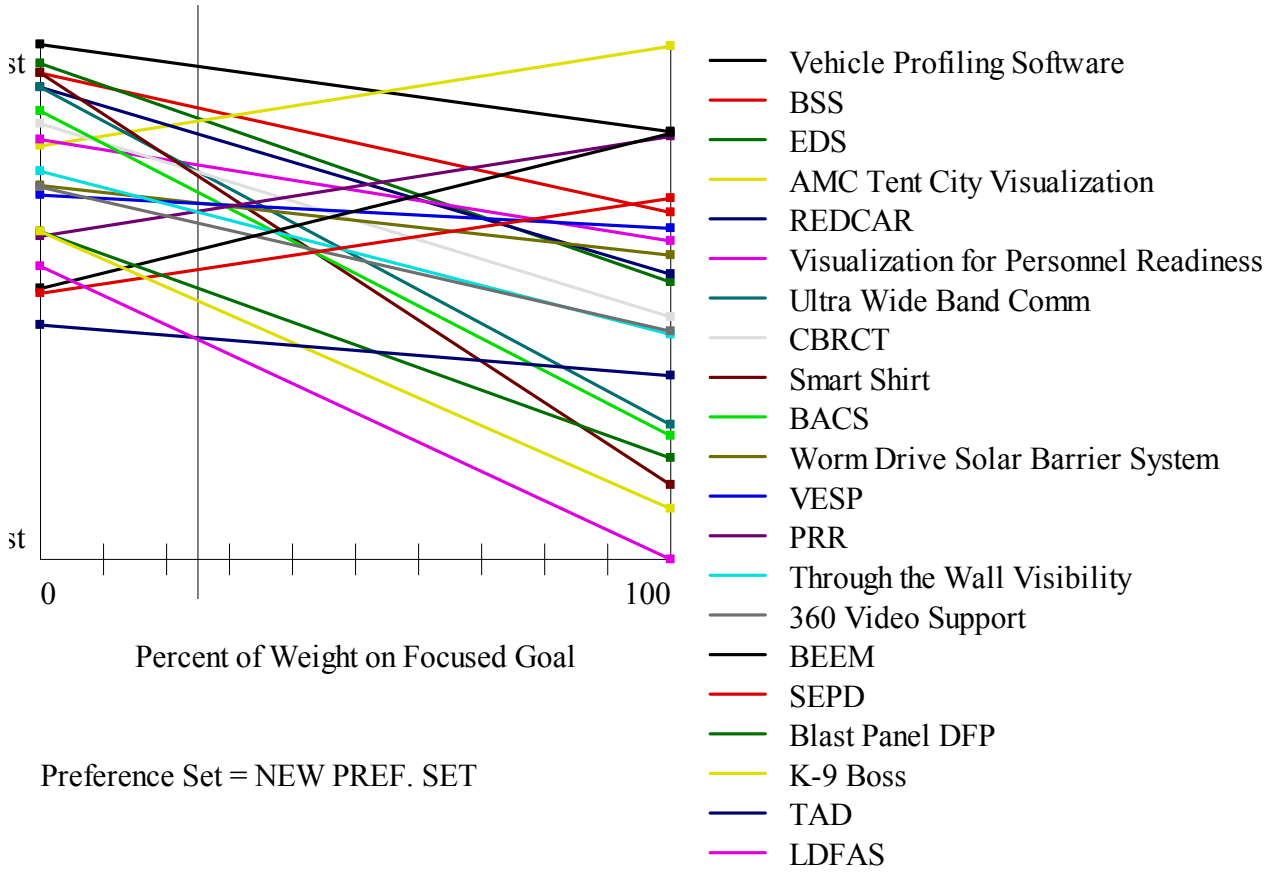


Figure 31. Sensitivity Results Focused Value

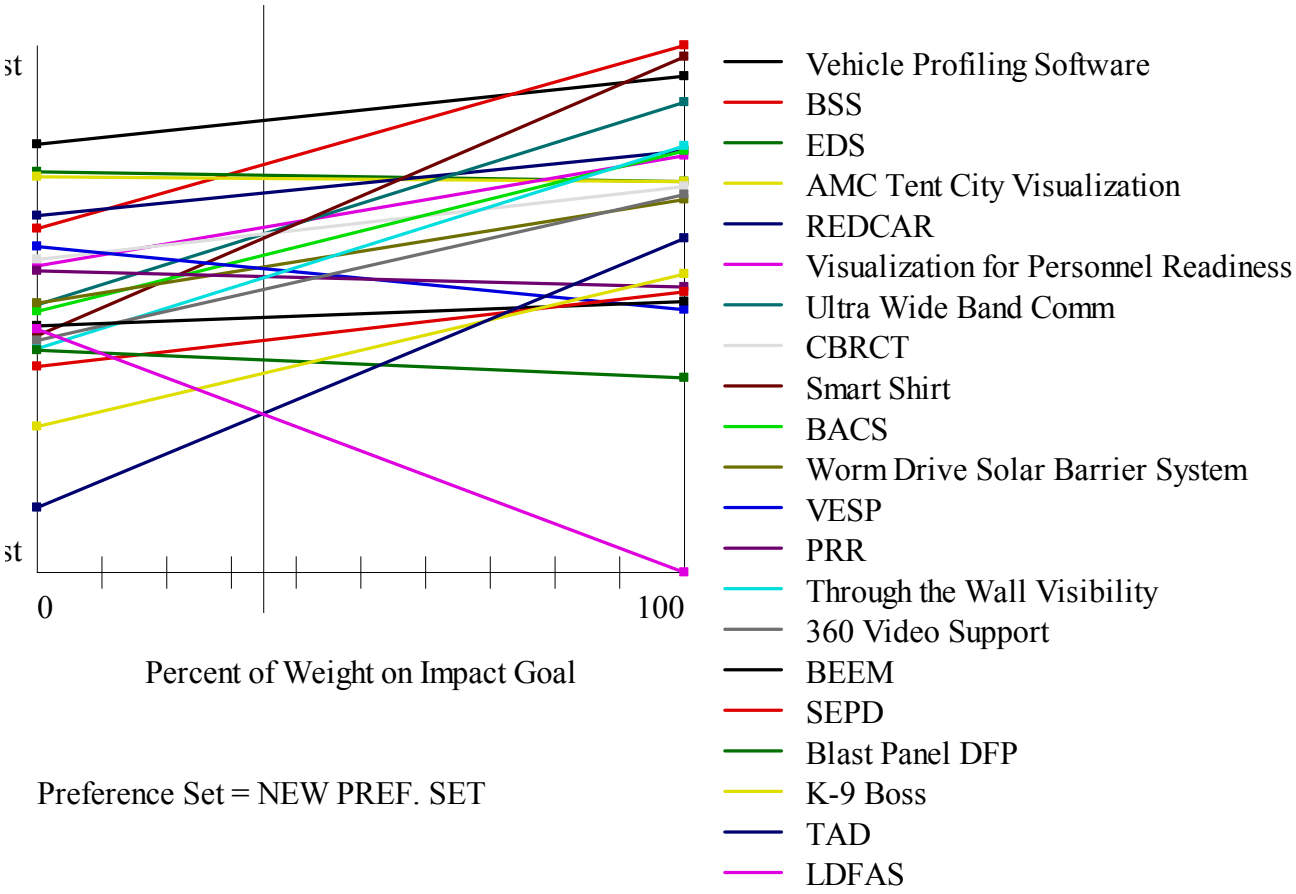


Figure 32. Sensitivity Results Impact Value

Table 21. Matrix of SDVF scores for Initiatives

Alternative Name	F/P Time	Any AFSC as AO	Infrastructure Location	Favorability of Disbursement	Total Est Initiative Cost
Vehicle Profiling Software	Part Time	Potentially	Combination	Favorably Disbursed	Low
Ultra Wide Band Comm	Full Time	No	Combination	Favorably Disbursed	Intermediate
Worm Drive Solar Barrier System	Part Time	No	Combination	Favorably Disbursed	Low
Through the Wall Visibility	Full Time	No	Combination	Not Disbursed	Intermediate
Blast Panel DFP	Part Time	Yes	External	Favorably Disbursed	Reasonable
LDFAS	Part Time	Yes	Combination	Not Disbursed	Low
VESP	Part Time	Yes	Internal	Not Disbursed	Reasonable
AMC Tent City Visualization	Part Time	No	Internal	Favorably Disbursed	Low
360 Video Support	Full Time	No	External	Favorably Disbursed	Reasonable
Visualization for Personnel Readiness	Full Time	Potentially	Internal	Favorably Disbursed	Intermediate
PRR	Part Time	Yes	Combination	Not Disbursed	Low
SEPD	Full Time	No	External	Favorably Disbursed	Reasonable
K-9 Boss	Part Time	Potentially	External	Unfavorably Disbursed	Intermediate
BACS	Full Time	Potentially	Internal	Not Disbursed	Low
TAD	Part Time	Potentially	External	Not Disbursed	Low
Smart Shirt	Part Time	No	Internal	Not Disbursed	Low
EDS	Part Time	Potentially	Combination	Not Disbursed	Reasonable
REDCAR	Full Time	Yes	Combination	Favorably Disbursed	High
BEEM	Part Time	No	External	Not Disbursed	Low
CBRCT	Part Time	No	Combination	Not Disbursed	Low
BSS	Part Time	No	Combination	Unfavorably Disbursed	Low

Alternative Name	% Cost bore by others	innovativeness	Degree of FP correlation	Degree of Similarity	Quantum Leap
Vehicle Profiling Software	High	Totally Innovative Purpose	Direct	Very Different	Mostly Developed
Ultra Wide Band Comm	Moderate	Totally Innovative Purpose	Direct	Very Different	Just in Theory
Worm Drive Solar Barrier System	Low	Totally Innovative Purpose	Direct	Similar	Readily Available
Through the Wall Visibility	Moderate	Totally Innovative Purpose	Direct	Different	Mostly Developed
Blast Panel DFP	Low	Totally Innovative Purpose	Direct	Similar	Mostly Developed
LDFAS	Moderate	Modified Purpose	Direct	Different	Mostly Developed
VESP	Low	Modified Purpose	Direct	Similar	Readily Available
AMC Tent City Visualization	Low	Totally Innovative	Direct	Similar	Mostly Developed

Alternative Name	% Cost bore by others	innovativeness	Degree of FP correlation	Degree of Similarity	Quantum Leap
		Purpose			
360 Video Support	Low	Totally Innovative Purpose	Direct	Very Different	Mostly Developed
Visualization for Personnel Readiness	Moderate	Modified Purpose	Direct	Very Different	Mostly Developed
PRR	Low	Intended Purpose	Direct	Similar	Readily Available
SEPD	High	Intended Purpose	Direct	Identical	Just in Theory
K-9 Boss	None	Totally Innovative Purpose	Direct	Different	Mostly Developed
BACS	High	Totally Innovative Purpose	Direct	Different	Mostly Developed
TAD	High	Modified Purpose	Limited	Similar	Mostly Developed
Smart Shirt	Very High	Totally Innovative Purpose	Direct	Similar	Mostly Developed
EDS	High	Totally Innovative Purpose	Direct	Very Different	Just in Theory
REDCAR	Low	Totally Innovative Purpose	Direct	Different	Just in Theory
BEEM	Very High	Intended Purpose	Direct	Similar	Readily Available
CBRCT	High	Totally Innovative Purpose	Direct	Different	Mostly Developed
BSS	High	Totally Innovative Purpose	Direct	Different	Mostly Developed

Alternative Name	Unit Status	Urgency	Lvl of Request	Time to Complete	Cost Risk	Sched Risk
Vehicle Profiling Software	AD	Urgent	HQ Air Force	Slow (12-18 mths)	Low	Medium
Ultra Wide Band Comm	None	Routine	# AF	Slow (12-18 mths)	Low	Medium
Worm Drive Solar Barrier System	AD	Routine	MAJCOM	Relatively Quick (6-12 mths)	Medium	Low
Through the Wall Visibility	AD	Routine	MAJCOM	Slow (12-18 mths)	Medium	High
Blast Panel DFP	AD	Routine	Base Level	Slow (12-18 mths)	Medium	Medium
LDFAS	None	Routine	Unit	Relatively Quick (6-12 mths)	Low	Low
VESP	AD	Urgent	HQ Air Force	Slow (12-18 mths)	Medium	Medium
AMC Tent City Visualization	AD	Priority	MAJCOM	Relatively Quick (6-12 mths)	Low	Low
360 Video Support	AD	Urgent	Unit	Quick (<6 mths)	Low	Low
Visualization for Personnel Readiness	AD	Priority	HQ Air Force	Slow (12-18 mths)	Medium	Medium
PRR	AD	Priority	MAJCOM	Relatively Quick (6-12 mths)	Low	Low
SEPD	AD	Priority	MAJCOM	Slow (12-18 mths)	Medium	High
K-9 Boss	AD	Urgent	Unit	Slow (12-18 mths)	Low	Medium
BACS	AD	Urgent	Base Level	Slow (12-18 mths)	Low	Low
TAD	AD	Urgent	Base Level	Slow (12-18 mths)	Medium	Low
Smart Shirt	AD	Routine	# AF	Very Slow (>18 mths)	Low	Low
EDS	AD	Priority	HQ Air Force	Very Slow (>18 mths)	High	High
REDCAR	AD	Routine	HQ Air Force	Slow (12-18 mths)	Medium	Medium
BEEM	AD	Urgent	MAJCOM	Slow (12-18 mths)	Low	Low
CBRCT	AD	Urgent	MAJCOM	Very Slow (>18 mths)	Medium	Medium
BSS	AD	Priority	HQ Air Force	Slow (12-18 mths)	Medium	High

Alternative Name	Perf Risk	Sensible	Degree (Tech)	Mult Tech	Degree (venues)	Degree (expertise)
Vehicle Profiling Software	Low	Very	All	Yes	Some	All
Ultra Wide Band Comm	High	Very	All	Yes	Some	Some
Worm Drive Solar Barrier System	High	Very	Some	Yes	None	All
Through the Wall Visibility	High	Somewhat	All	Yes	Some	All
Blast Panel DFP	Medium	Very	Some	No	Some	All
LDFAS	Medium	Somewhat	Some	No	All	None
VESP	Low	Very	Some	Yes	All	Some
AMC Tent City Visualization	Low	Very	All	No	Some	All
360 Video Support	Low	Very	Some	No	All	Some
Visualization for Personnel Readiness	High	Very	All	No	All	Some
PRR	Low	Very	All	No	Some	Some
SEPD	Medium	Somewhat	Some	Yes	Some	All
K-9 Boss	Medium	Very	Some	No	None	Some
BACS	Medium	Very	Some	Yes	Some	Some
TAD	Low	Very	All	Yes	Some	Some
Smart Shirt	Medium	Very	Some	No	Some	Some
EDS	High	Very	All	Yes	Some	Some
REDCAR	High	Very	Some	Yes	All	All
BEEM	Low	Very	All	Yes	All	All
CBRCT	Medium	Very	Some	No	Some	All
BSS	High	Very	Some	No	Some	All

Alternative Name	Degree (contracts)	# of Comps Advanced	Sign (Acq)	Sign (Doctrine)	Sign (Org)	Sign (Req)	Sign (Trng)
Vehicle Profiling Software	Some	3	Slightly	Very	Slightly	Very	Slightly
Ultra Wide Band Comm	Some	4	Slightly	Slightly	Slightly	Slightly	Slightly
Worm Drive Solar Barrier System	Some	2	Slightly	Slightly	Slightly	Slightly	Not
Through the Wall Visibility	Some	3	Slightly	Slightly	Slightly	Very	Slightly
Blast Panel DFP	Some	2	Slightly	Slightly	Not	Very	Slightly
LDFAS	Some	0	Slightly	Slightly	Not	Not	Not
VESP	All	1	Very	Not	Not	Slightly	Not
AMC Tent City Visualization	All	3	Slightly	Slightly	Slightly	Slightly	Very
360 Video Support	Some	3	Not	Slightly	Not	Slightly	Very
Visualization for Personnel Readiness	Some	4	Not	Slightly	Not	Slightly	Very
PRR	Some	1	Not	Slightly	Not	Not	Slightly
SEPD	All	1	Not	Not	Not	Slightly	Not
K-9 Boss	All	1	Not	Not	Not	Slightly	Not
BACS	None	3	Slightly	Not	Not	Slightly	Slightly
TAD	None	2	Very	Not	Not	Slightly	Slightly
Smart Shirt	Some	3	Very	Very	Very	Very	Slightly
EDS	None	3	Slightly	Not	Slightly	Slightly	Slightly
REDCAR	Some	3	Very	Slightly	Very	Very	Slightly
BEEM	Some	1	Slightly	Not	Not	Slightly	Slightly
CBRCT	Some	1	Slightly	Slightly	Slightly	Slightly	Very
BSS	Some	3	Slightly	Slightly	Slightly	Slightly	Slightly

Alternative Name	Extra Agency Involvement	Impact on Homeland Defense	Logistics Tail (measure)	Longevity	Time to Field	Lvl of Imp
Vehicle Profiling Software	Yes	Exclusively Homeland Defense	Average	Permanent	Intermediate (2-5 yrs)	Global
Ultra Wide Band Comm	Yes	Exclusively Homeland Defense	Average	Permanent	Long Time (5+ yrs)	Global
Worm Drive Solar Barrier System	Potentially	Exclusively Homeland Defense	Heavy	Permanent	Short Time (<2 yrs)	Global
Through the Wall Visibility	Potentially	Exclusively Homeland Defense	Heavy	Permanent	Intermediate (2-5 yrs)	Global
Blast Panel DFP	Potentially	Minimal to None	Average	Permanent	Intermediate (2-5 yrs)	Global
LDFAS	Yes	Moderate	Average	Permanent	Intermediate (2-5 yrs)	Global
VESP	Yes	Moderate	Average	Permanent	Short Time (<2 yrs)	Global
AMC Tent City Visualization	Potentially	Moderate	Minimal to None	Permanent	Short Time (<2 yrs)	Global
360 Video Support	Potentially	Moderate	Minimal to None	Permanent	Short Time (<2 yrs)	Global
Visualization for Personnel Readiness	Potentially	Moderate	Minimal to None	Permanent	Short Time (<2 yrs)	Global
PRR	Potentially	Moderate	Minimal to None	Permanent	Short Time (<2 yrs)	Global
SEPD	Yes	Exclusively Homeland Defense	Heavy	Permanent	Intermediate (2-5 yrs)	Global
K-9 Boss	Yes	Exclusively Homeland Defense	Average	Permanent	Intermediate (2-5 yrs)	Global
BACS	Yes	Exclusively Homeland Defense	Minimal to None	Temporary	Short Time (<2 yrs)	Global
TAD	Yes	Exclusively Homeland Defense	Average	Temporary	Intermediate (2-5 yrs)	Global
Smart Shirt	Yes	Exclusively Homeland Defense	Heavy	Permanent	Intermediate (2-5 yrs)	Global
EDS	Yes	Exclusively Homeland Defense	Average	Permanent	Long Time (5+ yrs)	Global
REDCAR	Potentially	Moderate	Average	Permanent	Short Time (<2 yrs)	Global
BEEM	Yes	Moderate	Average	Permanent	Short Time (<2 yrs)	Global
CBRCT	Yes	Exclusively Homeland Defense	Average	Permanent	Intermediate (2-5 yrs)	Global
BSS	Yes	Exclusively Homeland Defense	Minimal to None	Permanent	Short Time (<2 yrs)	Global

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Vita

Captain Robert P. Eskridge graduated from Lamar Consolidated High School in 1993 and entered undergraduate studies at Louisiana State University. He earned a Bachelor of Science degree in Civil Engineering from the University and was commissioned through the Reserve Officer Training Corps, Detachment 310 in August 1998.

His first assignment was to Lackland AFB, Texas. While there, he served as a deputy flight commander in the 37th Communications Squadron. After cross training into the civil engineering career field, Captain Eskridge served as the base civil engineering program manager in maintenance engineering as well as project manager for numerous efforts in the engineering and design flight of the 37th Civil Engineer Squadron. In August 2001, he entered the Engineering and Environmental Management Program, Graduate School of Engineering and Management, Air Force Institute of Technology. Following graduation, Captain Eskridge will join the Air Force Operations Test and Evaluation Center (AFOTEC) staff at Kirtland AFB, NM.

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14. ABSTRACT

With the recent increase in terrorist activity, force protection has become a key issue for the Department of Defense. Leading the research for new ideas and concepts in force protection for the US Air Force, is the Air Force Force Protection Battlelab (FPB). The FPB is charged with searching out force protection ideas and selecting those most worthy for future consideration. In 2002, a Value-Focused Thinking (VFT) hierarchy was created to help the FPB select those ideas that provided the most value to the Air Force and its force protection goals. This research effort uses the Future Value Analysis (FVA) approach, a decision making methodology to provide a more accurate project selection tool to the FPB. FVA incorporates the ideals of multi-attribute utility theory, specifically using the VFT process, as well as linear programming optimization techniques, to provide an optimal portfolio of initiatives for the FPB to pursue. FVA provides a solution that optimizes the value of initiatives selected, while remaining within the organizational constraints of the FPB. This research provides a proof of implementation for the FVA process in the force protection environment.

15. SUBJECT TERMS

Future Value Analysis, Value-Focused Thinking, Decision Analysis, Project Selection, Force Protection, Multi-Attribute Utility Theory, Linear Programming, Optimization

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